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MEDICAL EDUCATION IN THE UNITED STATES[1]

HISTORICAL

THE first medical school in the United States was organized in 1765 in connection with the University of Pennsylvania by Dr. W. Shippen, the anatomist, and Dr. John Morgan, both of whom had been favorite pupils of the Hunters in London and were graduates of Edinburgh. The Harvard Medical School was founded in 1783 by Dr. John Warren, who had been a military surgeon in the army from the battle of Bunker Hill until ill health forced his retirement. Anatomy was taught by demonstrations, but in 1809 a room was opened which offered to students opportunities for dissection similar to those given by the Hunters in London. It is stated that these facilities were superior to those obtainable on the continent of Europe.

As time went on there was a great increase in the number of medical schools; the older schools either dropped their university affiliation or this became nominal. The "proprietory school" arose, in which a few practising physicians came together for the purpose of giving lecture courses and clinics to medical students during a period of five months each year. The students listened to the same courses during two successive terms and, after passing an examination, received the degree of M.D. eighteen months subsequent to the beginning of their medical studies. Attempts to raise the standard of medical education were always accompanied by a loss of fees,

[1] A report prepared for the International Conference on Post-graduate Medical Education held at the time of the Seventeenth International Medical Congress, London, 1913.

the mass of the students invariably going to the medical school which offered the medical degree in the shortest and cheapest manner. In the later days of the proprietory school, some of the faculties divided their fees so that each professor who had taught four hours a week, during five months in the year, received eight or ten thousand dollars for his services.

The schools not being endowed could not exist with a high standard. At first they served an excellent purpose in the widely separated and rapidly growing communities in which they were situated. It must be remembered how different the conditions were from those existent in the densely settled countries of Europe with their well-endowed institutions of learning.

Prior to 1870, no laboratories existed except those of anatomy, so that the expense of maintenance of the proprietory medical school could always be kept at a minimum, and large sums could be distributed among its beneficiaries. This was the general condition of affairs as late as fifteen years ago. Professorial positions were often obtained by the ability to control a hospital service, family influence or personal friendship. These conditions persist, in part, to-day. Many able men were thus drafted, but also many mediocrities achieved thereby unearned distinction in the community. The conditions existing in Harvard, one of the best schools, during the régime of the two-year course, showed that the student was compelled to listen to as many as five successive lectures on a single day between the hours of nine and two o'clock on such diversified subjects as materia medica, chemistry, medicine, obstetrics and anatomy. The last hour was assigned to anatomy, for Dr. Oliver Wendell Holmes was the only one who could hold the exhausted student's attention.[2]

[2] "Life and Letters of Oliver Wendell Holmes."

The old-time school, now little more than a memory, has been dwelt upon because of the powerful influence it has had in yielding a mass of mediocre physicians whose existence can not, in any other manner, be explained. Some American physicians kept abreast of the world's knowledge, but conditions were such that the great mass of their pupils were started ill-educated on their careers on account of lack of opportunity and lack of the inculcation of the right ideals. This faulty education could only be remedied in a few instances by personal industry or by foreign study. Eminent professors assured their students that they were receiving the best education the world afforded, and yet, in 1871, Germany had eighteen of its present twenty regularly established institutes of physiology, at the same time that Bowditch, fresh from Ludwig's laboratory, modestly offered to senior medical students "opportunities for original investigations in the laboratory." It was also in 1871 that Eliot introduced a graded three-year course at the Harvard Medical School. This was symptomatic of the broader cultural development of a provincial people which followed the struggles of the civil war, and yet it is only within the last ten years that laboratories, other than those of anatomy and gross pathology, have become acknowledged essentials of medical schools of the highest class. It is due to this fact that the discipline in anatomy was always strong and rigorous. The controlling influence over the anatomical department was the professor of surgery who had advanced directly through that path, and the younger men in charge of the dissections were practising surgeons who hoped to become skillful through exact anatomical knowledge. All emphasis was laid upon practical application, and a huge mass of memorized details were crowded into the brain of the submissive student.

The intimacy between anatomy and surgery and the rigor of the discipline did much to equip American surgeons with a practical power which was of great value. This relation is shown to-day in the examination questions asked by the old-school surgeon, which are frequently half of them questions of anatomy.

THE FIRST TWO YEARS OF MEDICAL EDUCATION

With the development of higher scientific standards, the teaching of anatomy has been turned over to specialists, preeminent of whom is F. P. Mall. The twenty leading medical schools in the United States have anatomical laboratories, in charge of full-time professors, with competent, trained assistants, engaged in teaching and research. These laboratories also embrace embryology and histology. Some of the laboratories have come under the influence of the teachings of the American biologists, of men like C. S. Minot, E. B. Wilson, T. H. Morgan, E. G. Conklin, Charles B. Davenport, R. G. Harrison and Jacques Loeb. The mention of these names is prophetic of accomplishment when American medical schools shall be so organized that they can produce masters of modern medicine.

Reference has been made to Bowditch's influence at Harvard, but physiology in America also owes an important debt to H. Newell Martin of the English school. Martin established a graduate school in physiology at the Johns Hopkins University in 1876, and inspired many of the best workers in the country in physiology and biology. At present the better medical colleges have well-equipped physiological laboratories with full-time professors. The English system of obligatory student instruction in the physiological laboratory has been adopted and extended in the United States.

For the development of physiological chemistry, the country owes much to Chittenden, who studied with Kühne, and who, with tireless energy and fine capacity, trained numerous pupils who have charge of departments of physiological chemistry to-day. Under the old proprietory school system, there was, necessarily, a professor of chemistry who taught the elements of the science. It has, therefore, been an easy task to develop a special department of physiological chemistry in connection with all of the better schools. This has been very helpful, since there has been no department of medical science the world over which has more broadly developed during late years. Practical laboratory exercises for all the students are compulsory.

The English can well realize the influence which Cushny, a pupil of Schmiedeberg, has exerted in establishing pharmacology in the United States. Through his pupils, and through Abel and Sollman and their pupils, medical students are, themselves, able to experimentally determine the behavior of drugs upon the anesthetized, functionating organism.

The new German pathology was introduced into the country, by W. H. Welch, at the Bellevue Medical College and by T. Mitchell Prudden, at Columbia, who were both in New York City during the seventies and early eighties. New York was not then a scientific center, and the Johns Hopkins University, in 1884, offered Welch a professorship of pathology, which subsequently led to the development of a life of great usefulness, of unselfishly exerted power, and well-deserved distinction. The spirit of the influence was shown in a speech at a dinner given in New York seven years ago in honor of Friedrich Müller when Welch said: "It is through the laboratory that Germany has attained her primacy in medicine, and she will not

yield that primacy *because she knows what is good for her.*" Many excellent men have been trained in Welch's laboratory and through them, as well as through pupils of Prudden, pathology is well taught in the better American schools. One very great handicap to medical progress lies in the laws relating to the autopsy of the hospital dead. In the seventies, when E. G. Janeway and Francis Delafield were laying the foundation of their masterful comprehension of the science of medicine, it was easy for them to follow the course of disease and see the results at autopsy if the patient died. But now the New York law forbids an autopsy without consent of the next of kin, instead of accepting the more rational plan of permitting autopsy unless objection is offered within twenty-four hours by the next of kin. The difficulties to be overcome before an autopsy is allowed are such that only 10 per cent. of the patients dying in Bellevue Hospital, with its twelve hundred beds, are actually autopsied. A grotesque reflection upon this foolish system is shown in the fact that these 10 per cent. of autopsies indicate incorrect diagnosis in a large percentage of the cases. The following is the record in one large public hospital of 390 autopsies in the year 1912, as compiled by Oertel.

	Cases	Per Cent.
Clinical diagnosis confirmed.....	87	22.3
Clinical diagnosis correct but important additional lesions found.....	116	29.7
Clinical diagnosis partly correct.....	54	13.8
Clinical diagnosis not confirmed.....	109	27.9
No clinical diagnosis.....	24	6.3
	390	100.0

If the physician were sure that, in case of death, his diagnosis would be checked by the pathologist, he would be likely to exercise greater care in his work, and he and his pupils would learn to better understand the limitations of diagnosis. Also, the value of vital statistics would be immeasurably enhanced.

This very ill-advised policy on the part of the law-making power has had a further effect of discouraging pathological morphology, so that many pathological laboratories have turned attention to experimental pathology or experimental medicine, for which latter separate departments have sometimes been instituted. The enforced neglect of morphological pathology has been a grave obstacle in the path of medical progress.

THE SECOND TWO YEARS OF THE MEDICAL COURSE

For thirty years, it has been possible to train laboratory workers in the medical sciences according to the best principles, and in increasing measure both men and opportunity have been developed. It seems passing strange that, with all this activity, it is only very recently that the clinical situation has been touched. Men have passed through the schooling of the laboratories, and then, for two final years of education, have been, and usually still are, turned over to clinicians the majority of whom have had no laboratory training, and the student has graduated, and still graduates, without knowing the application of the fundamental medical sciences to the practise of his profession. Halliburton has epitomized the situation in the words, "The student forgets his physiology at the bedside." It is well for the clinician to assure the teachers of the fundamental sciences that they do best when they emphasize the importance of the practical application of their scientific knowledge, but this is only half the story. The more important half lies in the necessity that the clinical teacher should know in what way the fundamental sciences are helpful in the understanding of medicine.

The conditions in the United States have only recently so begun to improve that there begins to be a distinct incentive for a young clinician to definitely formulate a career as a medical teacher. Three years ago, in New York City, there was no hospital which could offer a continuous service. If any one were interested in scientific research, he might work for three months in his wards, at the end of which time he was turned out by a successor who might care nothing for research. The admirable example of the close affiliation between the hospital and medical school at the Johns Hopkins was long ignored. The whole situation was most unsatisfactory from an educational standpoint.

At the present time Columbia has formed an affiliation with the Presbyterian Hospital, the Cornell Medical School one with the New York Hospital, similar alliances exist in Cleveland, St. Louis and in other localities and, in Boston, the Harvard Medical School controls the appointments to the Peter Brent Brigham Hospital. The arrangements are, for the most part, temporary and experimental. The last-named union has enabled the new Brigham Hospital and the Harvard Medical School to attract from different parts of the country some of the best minds in the United States. It is of happy augury that men who, often at the expense of poverty and mental anxiety, of illiberal criticism and even of personal abuse, have labored to attain high professional rank through scientific endeavor, should be given the opportunity to achieve a better condition of medical scholarship. There is here embodied the true spirit of the possibility of conquest of the material by the intellectual. The appointments at Harvard were made for merit and were not due to local celebrity or to the desire to satisfy relatives or personal associates. Of all the traditions inherited from the days of the proprietory school, the faculty perquisite of the appointment of local mediocrity to important clinical positions dies the hardest. It is still too easy to appoint to a professorship a man without scientific or educational interests. Yet such misuse of power is gradually becoming less and less possible.

There has been much discussion of late years regarding the duties of a university professor of a clinical subject. Effort has been made to have him renounce all private practise. This ideal state has not yet been put to the test but arrangements are now in progress for its introduction into one of the best schools. President Vincent, of the University of Minnesota, presents the unsolved problem of the clinical teacher in the following words:

> You realize how difficult it is to persuade a man who is making $25,000 a year from his practise on the outside to accept a position of $3,000 on the inside. If you can get hold of the unsophisticated medical man before he owns an automobile, much may be accomplished, but after he once yields to the insidious motor car, nothing can be done in the way of regeneration.

The best class of university professors accept only a strictly consultation practise and do not receive patients for treatment except in their own hospitals. The professor of medicine at Columbia has devoted five hours daily to his work in the school and the affiliated Presbyterian Hospital, and his associate does not practise. Herein lies the kernel of reformation. The university should emphatically require that the welfare of its affiliated hospital, the patients therein and the throng of young physicians who are being educated, should be considered as of at least equal importance to the maintenance of regular office hours by the physicians in charge. Progress in the right direction is now being accomplished. The increasing spirit of

scientific research among the younger men is sign of hope for the future.

The hospital teaching of medical students is being rapidly improved by the introduction of the English system of clinical clerks, which was first used in America by Osler at the Johns Hopkins. Patients are assigned to different students who follow carefully the course of the disease, using laboratory methods, and perhaps finally preparing a thesis upon a group of cases or some particularly interesting case, presenting also the literature concerning similar cases. Some of these theses are worth publishing and thus approach the German "Doktorarbeit."

The special medical subjects, such as the eye, ear, etc., are treated by local specialists, as is the custom elsewhere. At the Johns Hopkins, special hospitals for psychiatry and for pediatrics have recently been opened and placed under the direction of first-class men.

After receiving his diploma, the medical student usually spends a year or two as a hospital interne. The Council on Medical Education of the American Medical Association reports that of 2,004 physicians graduating during a year from 40 of the better class medical schools, 1,403 or 70 per cent. received hospital internships. At Harvard, 90 per cent. of the men followed this custom. It is strongly advised by the council that a year of hospital internship be made compulsory before license to practise medicine is allowed. The 4,000 hospitals in the country would afford ample facilities.

Mention should be made of the influence of the Rockefeller Institute in New York, the McCormick Institute for Infectious Diseases and the Sprague Memorial Institute in Chicago, the Wistar Institute of Anatomy in Philadelphia and other examples of well-endowed research institutions which, for the most part, have set an example of idealistic accomplishment that has been of aid to the development of higher aims of medical achievement. It would be of little value to set forth at this time the extent and cost of buildings devoted to medical education in the United States for the essential factor is the spirit of the institutions themselves rather than their material embodiment. In commenting on the behavior of a certain young professor who complained that he could not work on account of lack of laboratory facilities, Carl Voit once said: "Er ist faul. Er will nicht arbeiten. Man kann in einem ganz kleinen Zimmer arbeiten." It is not lavish expenditure but the right spirit that is needed.

INFLUENCE OF AGENCIES FOR PUBLIC WELFARE

There have been various helpful agencies at work which have wrought wonderful advances in medical education in the United States. The country is thought to be naturally conservative, and the medical profession especially so. The cause of this is partly explained by quoting Vincent again.

> They (the American people) usually display hostility or, at least, derisive disrespect for the specialized and their opinions. To the unspecialized average man, the expert is in a way a personal affront. He suggests the idea of a superior class and seems to reflect on the competence of the ordinary citizen. This feeling is a natural survival of the early days, especially on the frontier.

To complete the picture and show how difficult is reform in America, whether of medical education or of the tariff or of the currency, one has only to recall the remark of A. B. Macallum that the progress of the world is accomplished by one thousandth of one per cent. of its inhabitants.

The battle for correct principles and ideals regarding medical education has

been waged by certain of the medical men themselves who have been unsparing critics of the old-fashioned methods.

Helpful agencies have been especially the Council on Medical Education of the American Medical Association composed of six individuals, and Abraham Flexner, who prepared a report on the condition of the medical schools of the country for the Carnegie Foundation.

The medical problem is not a simple one. There are 49 states and each state has its own examination for the license of its physicians. There is no national control, and the standards vary greatly. Thus, in twenty-seven states, the law gives the licensing board the power to refuse recognition to the graduates of low-grade medical colleges, a power too little made use of. In four states, it is not even necessary that an applicant for medical license be a graduate of a reputable medical college, and the authorities of Tennessee, in 1912, presented the spectacle of licensing 175 individuals who were not graduates of any medical school whatever.

In 1904, when the Council on Medical Education began its activities, there were 166 medical schools in the country, which was about one half of the world's supply. There are now 110 in contrast with 21 in England, 20 in Germany, 20 in Italy and 5 in France.

The reduction in the number of medical schools by extinction or merger has been the happy outcome of severe and public criticism. The Council on Medical Education set to work to bring about conformance to certain standards which may be thus abbreviated: (1) A higher entrance requirement which includes a year's work in chemistry, physics and biology, as given in the universities. (2) The presence of at least six full-time professors in the fundamental sciences in charge of thoroughly equipped laboratories in which the student works during his first two years. (3) Two years of clinical work in hospitals and dispensaries. (4) A post-graduate year as interne in an approved hospital. (5) The medical teaching to be of high excellence.

As an instance of notable accomplishment, it may be stated that whereas in 1904 only four of the 166 medical colleges required more than a four-year high school course for entrance, and the majority of the others admitted all who applied, at present sixty medical schools have adopted the higher entrance requirements and six states have adopted two years of university work as a necessary preliminary to the medical course.

An effective stimulus to medical education has come through the grading of medical schools into four different classes. This has been done as the result of personal inspection. The Council has recently published its third grading. In Class *A* Plus there are 22 acceptable medical colleges giving a four-year course. In Class *A* there are 31 colleges lacking in certain respects but otherwise acceptable and giving a four-year course. In Class *B* there are 22 colleges needing general improvement to be made acceptable and giving a four-year course. In Class *C* there are 27 colleges requiring complete reorganization to make them acceptable. Besides this, there are eight institutions offering only the first two years of medicine and there are four schools for the colored race, two in Class *A* and two in Class *C*.

The publication of these classifications has been of inestimable benefit in creating public sentiment against unworthy institutions. The work was greatly advanced in the Flexner report which gave detailed descriptions of abominable conditions in low-grade schools. Dr. Henry S. Pritchett,

head of the Carnegie Foundation, has recently stated that the full power of the foundation, to whatever extent may be necessary, will be used in the crusade against the worthless medical schools throughout the country. It is certainly right to insist upon the closing of a diploma mill, the physiological apparatus of which consists solely of a sphygmograph, when, in the same city, a physiological laboratory exists in which the annual budget reaches $30,000, and yet these two different medical institutions have been maintained under the laws of the same state, and, until this year, their graduates have been treated on equal footing by the state board of examiners. The fact that this low-grade school does not appear in the list of fully registered colleges this year shows how the state can use its power to protect its citizens. The legal power to defend the community from the ill-educated lies with the state boards who examine for the license to practise. In 1912, 5,466 physicians were so licensed as the result of examinations in the various states. A common standard would be highly desirable which would allow a physician licensed in one state to practise in another. At present it may happen that an impostor driven from one state can readily obtain a license to practise in another, and there continue his misdeeds. This condition of affairs will not much longer be tolerated.

CONCLUSION

It is lightly stated by some that the best American schools are equal to those of Europe. It would be satisfying if one could really believe that this were true. The American has never been self-satisfied and he is outgrowing his ancient habit of boasting, but he has always desired the best and there is much hope that out of present conditions he will some time evolve the best.

APPENDIX

1913. Class A Plus.—Acceptable medical colleges well organized and thoroughly equipped, giving acceptable courses and requiring for admission one or more years of university science. Prepared by the Council on Medical Education of the American Medical Association.

State	Town	Institution
California,	San Francisco,	Leland Stanford, Jr., University.
	San Francisco,	University of California.
Connecticut,	New Haven,	Yale Medical School.
Illinois,	Chicago,	Northwestern University Medical School.
	Chicago,	Rush Medical School (University of Chicago).
Indiana,	Indianapolis,	Indiana University Medical School.
Iowa,	Iowa City,	State University of Iowa.
Louisiana,	New Orleans,	Tulane University of Louisiana.
Maryland,	Baltimore,	Johns Hopkins University Medical Department.
Massachusetts,	Boston,	Harvard Medical School.
Michigan,	Ann Arbor,	University of Michigan.
Minnesota,	Minneapolis,	University of Minnesota.
Missouri,	St. Louis,	Washington University Medical School.
New York,	New York,	Columbia University.
	New York,	Cornell University.
	New York,	New York University and Bellevue Hospital Medical School.
	Syracuse,	Syracuse University.
Ohio,	Cincinnati,	University of Cincinnati.
	Cleveland,	Western Reserve University.

Pennsylvania,	Philadelphia,	University of Pennsylvania.
Texas,	Galveston,	University of Texas.
Virginia,	Charlottesville,	University of Virginia.

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THE BOTANICAL EXPLORATION OF AMBOINA BY THE BUREAU OF SCIENCE, MANILA

GEORGE EBERHARD RUMPF (Latin Rumphius) died in Amboina, Netherlands East Indies, in the year 1702, after a period of residence there of about thirty years. Some years after his death there was published in Amsterdam, under the editorship of J. Burmann, his great botanical work, the "Herbarium Amboinense." This monumental work consists of six folio volumes, comprising about 1,660 pages and 669 plates with approximately 960 figures, and with the accompanying "Actuarium" was published during the years 1741 to 1755. Linnæus did not receive a copy of the published parts until too late to incorporate the plants described in his "Species Plantarum." The work, then, as to nomenclature is pre-Linnæan, although binomial designations for the plants described are abundant in it.

The "Herbarium Amboinense" has at all times since its publication been a work of great botanical interest and is to-day one of the basic works for the student of the Malayan flora. For the proper interpretation of many species proposed by later authors, by citation of Rumpf, reference to the "Herbarium Amboinense" is absolutely essential.

In 1754 Olof Stickman, one of Linnæus's students, published his dissertation entitled "Herbarium Amboinense," a small pamphlet of 28 pages, which was reprinted by Linnæus in 1759 in his "Amœntates Academicæ," IV., pp. 112–143. In this work somewhat over 300 of the plants figured by Rumpf are reduced to species proposed by Linnæus in the first edition of his "Species Plantarum" (1753), or, by citation, are made the types of new ones. Constant references are made by Linnæus to the "Herbarium Amboinense" in his later works, so that very many of Rumpf's crude figures have become, by citation, the actual types of many Linnæan species. Later still other such species were proposed by Roxburgh, and by other authors, and Rumpf's plates are constantly being cited by modern authors in monographs and in papers on the Indo-Malayan flora.

Rumpf's plates, in many cases decidedly crude, being the only means by which a large number of proposed species can be interpreted, various attempts have been made more definitely to settle the status of the plants

figured and described by him. The first attempt comprehensively to treat Rumpf's plants was by A. W. E. T. Henschel, who published his "Clavis Rumphiana" in 1833, pages xiv + 215. In this work he attempted to reduce Rumpf's species, so far as possible, to modern binomial nomenclature. Thirty years later J. K. Hasskarl, a Dutch botanist having an extensive knowledge of the flora of the Malayan region, published his "Neuer Schlüssel zu Rumpf's Herbarium Amboinense," vi + 247 pages, originally printed in the *Abhandlung der naturforschenden Gesellschaft,* IX. (1866). Both of these works are unsatisfactory for the chief reason that a simple statement that a certain plate represents a certain species is frequently of little or no value, especially when the species is actually based on the plate, as is frequently the case.

In my work on the Philippine flora during the past ten years I have come very fully to realize that most of the species described by Blanco in his "Flora de Filipinas," none of which are represented by type material, can be accurately interpreted only by an intensive knowledge of the Philippine flora, as a whole, and a very special knowledge of the vegetation of those regions from which Blanco secured his botanical material, taking into consideration also habitats, dates of flowering and fruiting, economic uses and native names, in fact all data given by Blanco regarding each individual species. In many cases one must secure material from the actual localities cited by Blanco, and our recent collections must be compared with Blanco's descriptions not only as to the botanical characters given by him, but all other data. Similarly I have come to the conclusion that many of the species based on Rumpf's figures can be correctly interpreted and understood only by an intensive botanical exploration of the regions in which Rumpf collected his material, and a study of the specimens secured, taking into consideration all the data given by Rumpf and comparing it with data secured with botanical material from Amboina and neighboring islands.

Many of the species based wholly or in part on Rumpf's figures have been credited with a wide Indo-Malayan range, but in some cases, at least, the "species" are collective ones. Many others are not understood at all and appear in monographs as unrecognizable, doubtful or imperfectly known forms. We have in the Philippines many of the species proposed by the older authors which are typified by Rumpf's figures, and in critical genera, especially in those with numerous species, it is frequently quite impossible definitely to state which of our forms is the species based on Rumpf, and which is a distinct but closely allied one. The same principle holds true for the entire Malayan region.

In the case of many plants figured by Rumpf, there is absolutely no doubt as to the present status of such as the cocoanut, the papaya, the tamarind, the mango, the beetle-nut palm, and other well-known forms in monotypic or small genera. The difficulties arise in such genera as *Calamus, Canarium, Gnetum, Mucuna, Pandanus,* etc., where specific differences are frequently not very great. It is frequently quite impossible absolutely to delimit the species from the figures and descriptions given by Rumpf, and apparently no serious attempt has ever been made to interpret the species from actual Amboina specimens.

To illustrate this matter *Mucuna pruriens* DC. is based on *Dolichos pruriens* L. The original publication of *Dolichos pruriens* L. is in Stickman's "Herbarium Amboinense" (1754), 23, and is based absolutely and only on *Cacara pruiens* Rumpf Herb. Amboin., V., 393, *t. 142;* the question of specific identity of *Mucuna pruriens* is not complicated by any additional synonyms in the original publication of *Dolichos pruriens.* Most botanists assign to the species a pantropical distribution, as did Linnæus in his later publications; yet a simple examination of the material in any large herbarium will at once show that *Mucuna pruriens* is a "collective species," and that specimens so named really represent several more or less distinct species. No botanist can definitely state that he actually

knows just what *Mucuna pruriens* is, yet the species undoubtedly still grows in Amboina, and specimens from there which agree with Rumpf's figure and description will closely typify the Linnæan species. I assign to *Mucuna pruriens* a form that is not uncommon at low altitudes in the Philippines because, so far as I can determine, it agrees absolutely with Rumpf's figure; moreover the Philippine flora is very similar to that of the Moluccas. Yet other botanists refer to *Mucuna pruriens* quite different plants, and specimens that much less resemble Rumpf's figure than does the Philippine material. Now a prominent botanist has proposed to describe this Philippine form, my idea of *Mucuna pruriens,* as a new species, yet neither he nor I can definitely state whether it is or is not the form figured by Rumpf. I assume that it is, he assumes that it is not *Carcara pruriens* of Rumpf.

In 1788 Lamarck described a certain Rutaceous plant as *Fagara triphylla,* basing his description on a single Philippine specimen collected by Perrottet, and adding a reference to *Ampacus angustifolius* Rumpf Herb. Amboin., II., 188, *t. 62,* as illustrating the same species. In 1824 DeCandolle transferred Lamarck's species to *Evodia,* as *E. triphylla,* and until recently the species has been retained in that genus. An examination of Lamarck's actual type in the Muséum d'Historie Naturelle, Paris, shows it to be not an *Evodia* at all, but a *Melicope,* and a species known only from the Philippines. All botanists, however, have interpreted *Evodia triphylla* from Rumpf's figure, not from the actual type, and it has been given a range of from Tenasserim and Burma to Japan, China and Malaya. *Evodia triphylla* of modern authors contained at least three distinct species in two genera, and the number of synonyms is quite appalling.[1] Whether or not the Amboina *Ampacus angustifolius* is the same as the Philippine *Melicope triphylla* Merr. (*Fagara triphylla* Lam., *Evodia triphylla* DC.), it is impossible to determine at present, but the case illustrates remarkably well the errors in interpretation made by eminent botanists in attempting the identification of extra-Moluccan specimens with Rumpf's figures.

Recently Dr. O. Becarri has published his great monograph of the genus *Calamus,*[2] having access to most of the large European, Indian and Malayan collections. Rumpf figures eleven forms, on which ten species of *Calamus* have been based by later authors; yet Dr. Beccari, in spite of his great knowledge of the group, a personal knowledge of the Malayan species based on his own extensive Malayan collections, and in spite of the vast amount of material examined by him, was able definitely to recognize but four of these ten species. He states, *l. c.,* 90:

> The others represent, I believe, very well-marked species which will be recognized at some future time, because considering the period at which they were made, Rumpf's figures are very good and the descriptions, if properly understood, are quite reliable. I have therefore no doubt that these species will be found again in the Moluccas when these islands are better explored.

Some months ago I conceived the plan for a botanical exploration of Amboina, with the primary object of collecting in the original localities cited by Rumpf, actual botanical material that might represent the species, often so crudely figured by him, the actual field work to be done with a consideration of all the data given by Rumpf, localities, habitats, native names, uses, time of flowering and fruiting, etc. The plan as developed by the Bureau of Science was approved by the authorities in the Philippines, and has received the cooperation and support of the Dutch botanists at Buitenzorg, Java. The problem was assigned to Dr. C. B. Robinson, of the botanical staff of the Bureau of Science. Plans were perfected and he left Manila in June for Java and is now in Amboina, where he will prosecute botanical exploration for some months.

It is the ultimate plan to distribute the bo-

[1] Merrill, E. D., "On the Identity of *Evodia triphylla* DC.," *Philp. Journ. Sci.,* VII., 1912, *Bot.,* 373–378.

[2] *Ann. Bot. Gard. Calcutta,* XI., 1908.

tanical material thus secured to various institutions, authentically named with reference to modern nomenclature, and at the same time correlated, whenever possible, with Rumpf's figures and descriptions. It is felt that this particular piece of taxonomic research is one of the very greatest importance and the material we hope to secure should enable botanists generally very definitely to interpret and delimit many of the now doubtful species that have been proposed by citation of Rumpf's figures.

It is hoped that in case we succeed in solving some of the taxonomic problems which are dependent on a correct interpretation of species based on Rumpf's work, that our success may stimulate some other botanist to do for Rheede what we hope to do for Rumpf; that is, to collect and distribute a set of plants from the Malabar coast in India that shall represent those species figured by Rheede tot Draakenstein in his "Hortus Malabaricus," I.–XII., 1678–1703, a work of as great or greater importance than that of Rumpf in interpreting various Linnæan and other species.

Elmer D. Merrill

Bureau of Science,
Manila, P. I.

MARINE BIOLOGICAL LABORATORY INVESTIGATORS 1913

ZOOLOGY

Independent Investigators

Allee, W. C., Instructor in Zoology, Williams College.

Baitsell, George A., Graduate Student, Yale University.

Beckwith, Cora J., Instructor in Biology, Vassar College.

Binford, Raymond, Professor of Biology, Guilford College.

Boring, Alice M., Associate Professor of Zoology, University of Maine.

Breitenbecker, J. K., Instructor in Biology, Western Reserve University.

Browne, Ethel N., Dana Hall, Wellesley College, Instructor in Biology.

Budington, Robert A., Associate Professor of Zoology, Oberlin College.

Bullock, F. D., Associate in Cancer Research, Columbia University.

Calkins, Gary N., Professor of Protozoology, Columbia University.

Chambers, Robert, Assistant Professor of Histology and Comparative Anatomy, University of Cincinnati.

Child, C. M., Associate Professor of Zoology, University of Chicago.

Clapp, Cornelia M., Professor of Zoology, Mount Holyoke College.

Conklin, E. G., Professor of Biology, Princeton University.

Crampton, H. E., Professor of Zoology, Barnard College, Columbia University.

Drew, Gilman A., Assistant Director, Marine Biological Laboratory.

Edwards, Dayton J., Tutor in Physiology, College of the City of New York.

Glaser, O. C., Junior Professor of Zoology, University of Michigan.

Goldfarb, A. J., Instructor in Zoology, College of the City of New York.

Grave, Caswell, Professor of Zoology, Johns Hopkins University.

Grave, B. H., Professor of Biology, Knox College, Galesburg, Ill.

Gregory, Louise H., Instructor in Zoology, Barnard College.

Harvey, E. N., Instructor in Physiology, Princeton University.

Hegner, R. W., Assistant Professor of Zoology, University of Michigan.

Hogue, Mary J., Instructor in Zoology, Mount Holyoke College.

Hyde, R. R., Assistant Professor of Physiology and Zoology, Indiana State Normal School.

Jackson, Robert T., Professor of Paleontology, Harvard University.

Just, E. E., Professor of Zoology, Howard University.

Knower, H. McE., Professor of Anatomy, University of Cincinnati.

Lefevre, George, Professor of Zoology, University of Missouri.

Lillie, Frank R., Professor of Embryology, University of Chicago.

Lund, E. J., Adam T. Bruce Fellow, Johns Hopkins University.

McClung, C. E., Professor of Zoology, University of Pennsylvania.

McGregor, J. H., Professor of Zoology, Columbia University.

Mall, F. P., Professor of Anatomy, Johns Hopkins University.

Malone, E. F., Assistant Professor of Anatomy, University of Cincinnati.
Morgan, T. H., Professor of Experimental Zoology, Columbia University.
Morrill, C. V., Instructor in Anatomy, New York University.
Morse, Edward S., Director, Peabody Museum, Salem, Mass.
Newman, H. H., Associate Professor of Zoology, University of Chicago.
Painter, T. S., Instructor in Zoology, Roanoke College.
Pappenheimer, A. M., Associate in Pathology, Columbia University.
Parmenter, C. S., Vice-president and Professor of Zoology, Baker University, Baldwin, Kansas.
Paton, Stewart, Lecturer in Biology, Princeton University.
Patterson, J. T., Professor of Zoology, University of Texas.
Reinke, E. E., Fellow in Zoology, Princeton University.
Robertson, W. R. B., Assistant Professor of Zoology, University of Kansas.
Shorey, Marian L., Professor of Biology, Milwaukee-Downer College.
Shull, A. Franklin, Assistant Professor of Zoology, University of Michigan.
Spaeth, R. A., Research Student, Harvard University.
Spaulding, E. G., Assistant Professor of Philosophy, Princeton University.
Stockard, C. R., Professor of Anatomy, Cornell Medical College.
Strong, O. S., Instructor in Anatomy, Columbia University.
Strong, R. M., Instructor in Zoology, University of Chicago.
Thompson, Caroline B., Associate Professor of Zoology, Wellesley College.
Treadwell, A. L., Professor of Biology, Vassar College.
Van Cleave, H. N., Instructor in Zoology, University of Illinois.
Wilson, E. B., Professor of Zoology, Columbia University.
Woodruff, L. L., Assistant Professor of Biology, Yale University.

Beginning Investigators

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Carver, Gail L., Professor of Biology, Mercer University.
Dexter, John S., Fellow in Zoology, Columbia University.
Faust, E. C., Research Assistant, University of Illinois.
Fish, J. Burton, Graduate Student, Columbia University.
Glaser, R. W., Bussey Institution, Forest Hills, Boston, Mass.
Goodrich, H. B., Assistant in Zoology, Columbia University.
Hayden, Margaret A., Instructor in Biology, Carnegie Institute of Technology.
Heilbrunn, L. V., Laboratory Assistant in Zoology, University of Chicago.
Hoge, Mildred A., Graduate Student, Columbia University.
Isaacs, Raphael, Assistant in Zoology and Embryology, University of Cincinnati.
Linkins, R. H., Assistant in Zoology, University of Illinois.
Lynch, Clara J., Instructor in Zoology, Smith College.
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Shumway, Waldo, University Scholar in Zoology, Columbia University.
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Sturtevant, A. H., Graduate Student, Columbia University.
Wardwell, E. H., Assistant in Biology, Princeton University.
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PHYSIOLOGY

Independent Investigators

Bancroft, F. W., Associate Member in Department of Experimental Biology, Rockefeller Institute for Medical Research.
Bradley, H. C., Assistant Professor of Physiological Chemistry, University of Wisconsin.
Donaldson, H. H., Wistar Institute of Anatomy and Biology.
Ewald, W. F., Fellow, Rockefeller Institute for Medical Research.
Garrey, W. E., Associate Professor of Physiology, Washington University.
Hyde, Ida H., Professor of Physiology, University of Kansas.

Kite, G. L., Assistant in Physiological Chemistry, University of Chicago.
Knowlton, F. P., Professor of Physiology, Syracuse University.
Lillie, R. S., Assistant Professor of Experimental Zoology, University of Pennsylvania.
Loeb, Jacques, Head of Department of Experimental Biology, Rockefeller Institute for Medical Research.
Mathews, A. P., Professor of Physiological Chemistry, University of Chicago.
Meigs, E. B., Wistar Institute of Anatomy and Biology.
Moore, A. H., Associate Professor of Physiology, Bryn Mawr, College.
Morse, Max W., Trinity College, Hartford, Conn.
Tashiro, Shiro, Associate in Physiology, University of Chicago.
Wasteneys, Hardolph, Associate in Experimental Biology, Rockefeller Institute for Medical Research.
Wherry, W. B., Associate Professor of Bacteriology, University of Cincinnati.

Beginning Investigators

Adams, H. S., Fellow in Chemistry, University of Chicago.
Cattell, McKeen, Student, Columbia University.
Gould, H. N., Fellow in Biology, Princeton University.
Kanda, Sakyo, Fellow in Psychology, Clark University.
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Stringer, Caroline E., Head of Biology Department, Omaha High School.

BOTANY

Independent

Duggar, B. M., Research Professor of Plant Physiology, Washington University.
Garber, John F., Head of Botany Department, Yeatman High School, St. Louis, Mo.
Hibbard, Rufus P., Instructor in Plant Physiology, Michigan Agricultural College.
Lewis, I. F., Assistant Professor of Botany, University of Wisconsin.
Lyman, George R., Assistant Professor of Botany, Dartmouth College.
Moore, George T., Director, Missouri Botanical Gardens.
Nichols, Susan P., Associate Professor of Botany, Oberlin College.
Osterhout, W. J. V., Professor of Botany, Harvard University.
Snow, Laetitia M., Associate Professor of Botany, Wellesley College.
Stomps, Theodor J., Professor of Cytology, University of Amsterdam.
Wuist, Elizabeth D., 2351 East 5th Street, Dayton, Ohio.

Beginning Investigators

Colley, R. H., Instructor in Biology, Dartmouth College.
Curtis, Otis F., Instructor in Botany, Cornell University.
Davis, A. R., Lackland Research Fellow, Washington University.
Foster, Goodwin L., Graduate Student, Dartmouth College.
Hopping, Aleita, Tottenville, Staten Island, New York.
Robbins, W. J., Instructor in Plant Physiology, Cornell University.
Roberts, Edith A., Instructor in Botany, Mount Holyoke College.

THE MICROORGANISM CAUSING EPIDEMIC POLIOMYELITIS[1]

From the facts presented it follows that by employing a specially devised method there has been cultivated from the central nervous tissues of human beings and monkeys the subjects of epidemic poliomyelitis a peculiar minute organism that has been caused to reproduce the symptoms and lesions of experimental poliomyelitis. The microorganism consists of globoid bodies measuring from 0.15 to 0.3 of a micron in diameter, and arranged in pairs, chains and masses, according to the conditions of growth and multiplication. The chain formation takes place in a fluid medium, the other groupings in both solid and fluid media. Within the tissues of infected human beings and animals the chains do not appear.

No statement is ventured at present as to the place among living things to which the

[1] Concluding part of a paper by Dr. Simon Flexner and Dr. Hideyo Noguchi published in the *Journal of Experimental Medicine* for October.

bodies belong. It is obvious that the cultural conditions are those that apply more particularly to the bacteria.

On the other hand, the microorganism is associated with the production of an acute disease in which suppuration does not form a prominent part. No special attention at the present time has been given to the solution of the question as to whether the microorganism actually belongs to the bacteria or to the protozoa. In the manner of evolution of the symptoms, and in the appearance of the lesions, the experimental disease caused by the inoculation of the cultures resembles that produced by the virus of poliomyelitis as ordinarily employed. The central nervous organs of monkeys infected with the cultures bear preservation and glycerinization as do the infected human tissues, or the monkey tissues infected directly from human tissues. Cultures to which glycerin is directly added survive in the refrigerator at least eight days.

The microorganism passes through Berkefeld filters and the filtrates yield upon recultivation the particular microorganism contained within the filtered culture. Moreover, Berkefeld filtrates prepared from the nervous tissues of infected human beings and monkeys yield also in culture the identical microorganism.

By employing a suitable staining method the microorganism has been detected in film preparations and sections prepared from human nervous tissues, and from the corresponding tissues of monkeys inoculated with the usual virus or with cultures or filtrates prepared from monkeys previously injected with cultures. From all the infected materials mentioned, irrespective of the manner of their origin, the microorganism has been recovered in cultures. As would be expected it is more uniformly recoverable from the original nervous tissues than from filtrates, and doubtless for the reason that in the former it exists in greater abundance.

To obtain the initial culture is difficult, and this irrespective of whether the tissues submitted to cultivation have come immediately from man or from monkeys previously inoculated with the ordinary virus or even with the cultures. Once the microorganism adapts itself to a parasitic state it is developed with greater difficulty under saprophytic conditions. Whenever the nervous tissues have been shown to be infectious, the microorganism has been recoverable, notwithstanding long preservation and glycerination. In other words, infectivity of the nervous organs and the presence of the microorganism exist together. It has indeed happened that a specimen of infected nervous tissue has at the first attempt not yielded the initial growth, although it has yielded it upon the second attempt. Persistence will usually lead to a successful cultivation, provided no technical fault is committed. An important factor in the technique of cultivation is the sample of ascitic fluid. Not all samples are suitable, and a preliminary test is necessary, using for the purpose a growing culture, in selecting samples for culture purposes. Once a suitable ascitic fluid is obtained it should be carefully husbanded in the refrigerator. Even with this precaution failure may still occur. In such an instance repetition, using the same materials but in two series, one of which is prepared for enclosure in the anaerobic jar, while the other is allowed to remain outside, may yield the desired result; or the result may come on a second trial that appears to be an exact repetition of the first.

Only the exceptional cultures possess the degree of pathogenicity sufficient to cause specific infection, and the production of experimental poliomyelitis. A pathogenic strain may be effective at different and even remote generations, and a non-pathogenic strain may lack pathogenicity even in the second generation. This important fact indicates strongly that the pathogenic effect is not due to mere mechanical carrying over into the cultures of an invisible parasite or virus with which the cultivated microorganism is accidentally associated. If such accidental association were the cause of the experimental disease produced by the cultures in monkeys, it would display itself preferably in

the first generations and without reference to the strain of the visible microorganism. On the other hand, in this fluctuation of pathogenicity the cultures imitate the action of the virus as contained in human materials, namely, nervous tissue, secretions from the nasopharynx and intestinal washings, in which the virus, either known or believed to be present, may yet fail to be demonstrated by reason of the want of infectious power for monkeys or for the particular monkey inoculated in a given instance. Moreover, it is a common experience in bacteriology to find even among the ordinary bacteria lack or rapid loss of virulence among saprophytic cultures, while virulence is not only retained, but may be increased in rapid passages from animal to animal.

In view of these considerations it would appear that an etiological relationship has been shown to exist between the cultivated microorganism and epidemic poliomyelitis as it occurs in human beings or in monkeys. There remains merely a single other possibility, already indicated, namely, that two factors are present in the cultures, the one an invisible because ultramicroscopic organism, the other the globoid bodies described. On this basis it would have to be supposed that the former but hypothetical factor is the essential agent of infection. As against this supposition it may be urged that an instance of symbiosis of this nature is not known to animal pathology. Regarding the cultivated minute but visible microorganism itself, it may be held on the basis of the data presented that it fulfills the conditions hitherto demanded for the establishment of causal relation between an extraneous parasite and a specific disease. The microorganism exists in the infectious and diseased organs; it is not, as far as is known, a common saprophyte, or associated with any other pathological condition; it is capable of reproducing, on inoculation, the experimental disease in monkeys, from which animals it can be recovered in pure culture. And besides these classical requirements, the microorganism withstands preservation and glycerination as does the ordinary virus of poliomyelitis within the nervous organs. Finally, the anaerobic nature of the microorganism interposes no obstacle to its acceptance as the causative agent, since the living tissues are devoid of free oxygen and the virus of poliomyelitis has not yet been detected in the circulating blood or cerebrospinal fluid of human beings, in which the oxygen is less firmly bound; nor need it, even should the microorganism be found sometimes to survive in these fluids.

SCIENTIFIC NOTES AND NEWS

At the celebration of founder's day at Lehigh University, on October 3, the degree of doctor of laws was conferred upon Dr. Mansfield Merriman, from 1878 to 1907 head of the department of civil engineering, and on Professor Edward H. Williams, Jr., head of the department of mining and geology from 1881 to 1902.

Professor Eliakim Hastings Moore, head of the department of mathematics of the University of Chicago, was recently elected by the council as a corresponding member of the British Association for the Advancement of Science.

Dr. Arthur Shipley, professor of zoology and master of Christ's College, of Cambridge, will make one of the addresses at the formal opening of the graduate college of Princeton University, on October 22.

Dr. A. F. Blakeslee, who has been spending a year's leave of absence in research work in the Carnegie Station for Experimental Evolution at Cold Spring Harbor, L. I., has returned to the Connecticut Agricultural College, Storrs, Conn., where he is in charge of the department of botany.

Last summer the U. S. Weather Bureau, in cooperation with the Smithsonian Institution, made a series of balloon ascensions in southern California, with Mr. W. R. Gregg in charge of the field party. The latter part of July was spent at Catalina Island, and the first twelve days of August on the summit of Mount Whitney.

PRESIDENT WILSON has nominated Col. Dan C. Kingman, corps of engineers, as chief of engineers, with the rank of brigadier general.

DR. R. LÖWENHERZ has been appointed curator of the chemical museum of the Berlin School of Technology.

MR. W. F. FISKE has been requested by the Tropical Diseases Committee of the Royal Society to investigate the life-history of the tsetse flies in Uganda.

DR. HIDEYO NOGUCHI, of the Rockefeller Institute, New York, on September 23 presented the results of his researches on the etiology of rabies before the German Association of Men of Science and Physicians.

A REPORT on tropical diseases prevalent in Ecuador and adjacent republics is being made to Superintendent Smith, of the Johns Hopkins Hospital, by Dr. A. W. Sellards who was the representative of the Johns Hopkins Hospital in the expedition sent out by the Harvard Medical School, under the direction of Dr. Richard P. Strong.

THE Royal Geographical Society's specially designed Antarctic medals will be presented to the surviving members of the Scott expedition by Lord Curzon of Kedleston at a meeting of the society on November 10. At the same time, at the request of the Italian Geographical Society, the president will present to Lady Scott the great Humbert gold medal awarded by that society in memory of Captain Scott. Silver duplicates will be presented to Mrs. Wilson, Mrs. Oates, Mrs. Bowers and Mrs. Evans, widow of petty officer Evans.

THE Harveian oration before the Royal College of Physicians, of London, will be delivered by Dr. J. Mitchell Bruce, on October 18.

THE *School Review*, published by the University of Chicago Press, will hereafter be under the editorial charge of Rollo LaVerne Lyman, this year appointed associate professor of the teaching of English in the School of Education. Frank Nugent Freeman, instructor in educational psychology, has been placed in editorial charge of the *Elementary School Teacher*.

PROFESSOR LUCIEN AGUSTUS WAIT, emeritus professor of mathematics in Cornell University, with the faculty of which he was connected from 1870 until his retirement in 1910, has died, aged sixty-seven years.

DR. REGINALD FABER FITZ, professor emeritus in the Harvard Medical School, where for many years he was Shattuck professor of pathological anatomy, died on September 30, aged seventy years.

THE death is announced of Edward Gardner Murphy, who was active in educational and social matters, and under the name Kelvin McKready was the author of various publications in astronomy.

THE deaths are also announced of Mr. Samuel Roberts, F.R.S., president of the London Mathematical Society from 1880 to 1882, and De Morgan medallist in 1896, and of Mr. John Greaves, bursar and senior mathematical lecturer at Christ's College, Cambridge.

THE government through Secretary of Commerce Redfield has decided to change the sale of all the government catch of seal, fox and other Alaska furs, from London to St. Louis. At the present time St. Louis is said to be the largest primary fur market in the world. It is estimated that three fourths of all the furs trapped on the North American Continent are shipped to St. Louis houses to be sold.

THE British secretary of state for the colonies has nominated a committee to report: (1) Upon the present knowledge available on the question of the parts played by wild animals and tsetse flies in Africa in the maintenance and spread of trypanosome infections of man and stock. (2) Whether it is necessary and feasible to carry out an experiment of game destruction in a localized area in order to gain further knowledge on these questions, and, if so, to decide the locality, probable cost, and other details of such an experiment, and to provide a scheme for its conduct. (3) Whether it is advisable to attempt the extermination of

wild animals, either generally or locally, with a view of checking the trypanosome diseases of man and stock. (4) Whether any other measures should be taken in order to obtain means of controlling these diseases.

The production of gypsum in 1912 was the greatest in the history of the industry, according to the U. S. Geological Survey, the amount of gypsum consumed being 2,500,757 short tons. The value of gypsum and gypsum products was $6,563,908, an increase of $101,873 over 1911. In 1880 only 90,000 tons of gypsum were produced; in 1900 the production was 590,000 tons. The bulk of the gypsum produced in the United States is manufactured by grinding partial or complete calcination into the various plasters, such as plaster of Paris, molding and casting plaster, stucco, cement plaster, flooring plaster and hard-finish plaster. Refined grades of plaster are used in dental work, for making pottery molds, stereotype molds, molds for rubber stamps, and as an ingredient in various patent cements. A steadily increasing quantity is being used in the raw state as a retarder in Portland cement. Considerable quantities are ground without burning and used as land plaster; smaller quantities are used in the manufacture of paint, wall tints, crayons, paper, imitation meerschaum and ivory, and as an adulterant. The pure white massive form, known as alabaster, is much used by sculptors for interior ornamentation, less, however, in this country than abroad.

According to the *Scottish Geographical Magazine* the research vessel *Hiawatha,* chartered for fishery research in the North Sea, left the Tyne in August for the purpose of making certain practically continuous hydrographic observations, at a fixed position. She was to take part in a coordinated research into the movements of the great water masses in the North Sea, and for this purpose was to drop her anchor about 150 miles "E. by N. ½ N." of Shields. Her labors were to be identical in aim with researches simultaneously carried out on board eight other vessels, also at anchor. Two of these other vessels were to be research vessels, acting on behalf of Sweden and Scotland, the Swedish vessel working in the Skagerak, the Scottish well to the northeast of Aberdeen. The remaining vessels are light vessels, two acting for Holland and the other four for the English department. The observations were to consist of current measurements made near both surface and bottom every hour night and day throughout the fortnight, and in fine weather at other intermediate depths. Special attention was to be paid to the submarine waves which, it is expected, are to be met with at the depth at which the heavier bottom water and the lighter surface water are in contact. Specially devised current meters are used in this work. The temperature and salinity of the various layers of the sea were also to be ascertained, special water-bottles being employed to secure samples of the sea from any desired depth. Samples of the minute floating organisms which, directly or indirectly, constitute the food of all our food fishes were also to be taken at various depths and at the extremes of the tide. It is expected that some 8,000 independent current measurements would be made from the English vessels alone. The operations have been planned by a special committee of the International Council for the Exploration of the Sea, it is stated, because a knowledge of the constitution and movements of the sea water is essential to the understanding of the movements and of the abundance of the fishes upon which the fishing industry depends. For instance, the abundance or scarcity of the herring of the Kattegat and Skager Rack has been found to be connected directly with the amount of water which enters the Baltic from the North Sea, and other fisheries in southern Sweden have been shown to change with the ebb and flow of this layer of cold, salt water.

The U. S. Bureau of Mines has issued Bulletin 22, entitled "Analyses of Coals in the United States, with Descriptions of Mine and Field Samples collected between July 1, 1904, and June 30, 1910." This report contains the analyses of 5,000 samples of coal taken from 1,500 coal mines and prospects situated in the various coal fields of the United States. Not

only all of the important fields are represented, but practically all of the more important mining districts. The purpose of the bureau in compiling and publishing this information is to present reliable information regarding the chemical composition and heating value of the coals. The samples of coals were collected by experienced men according to a definite and uniform system, and were analyzed under carefully controlled conditions, so that there might be no question as to the relative merits of the different coals so far as this can be determined by chemical analyses and determination of heating values. An increasing proportion of the coal consumed in the power stations and the larger manufacturing plants of the country is now being purchased under specifications based on chemical analyses and calorimetric determinations of heat units. In the purchase of fuels many matters that have been left to chance are now carefully investigated. It is the aim of mechanical engineers to construct furnaces and to arrange the heat-absorbing surface in a furnace with reference to the peculiar character of the fuel which is to be burned. The report just issued by the Bureau of Mines is in two parts, one giving the methods used in collecting and analyzing the samples, and the results of the analyses, and the other giving the exact location from which each sample of coal was taken, together with a description of the characteristic features of the coal bed at the point of sampling, the nominal capacity of the mine, and such notes on the preparation of the coal as might be useful to consumers. The data contained in these two volumes is not equalled in scope and detail and in value for comparative purposes by the figures that have been published by any other coal-producing country in the world. The governments of some of these countries have published analyses of coals from different mines and from different districts but, with few exceptions, the samples of coal were not collected and analyzed under a uniform system that would make the results comparable in all respects, and no country has attempted to publish such a large number of analyses that would be comparable because of the care taken in collecting and analyzing the samples.

DURING the past fiscal year 4,686 predatory animals were killed by federal officers on the national forests, according to an actual count of carcasses. An indeterminate number of animals, whose bodies were not found, are presumed to have died from poison. The ranger's bag of beasts of prey this year, as shown by forest service figures, was made up of 206 bears, 3,541 coyotes, 133 mountain lions, 62 lynx, 583 wild cats, 64 wolves and 97 wolf pups. The figures indicate that the national forests are becoming cleared of wild animals that prey upon domestic livestock and game, for the forest ranger fills in odd moments between other jobs by thinning out "undesirable citizens" of the animal world. Wolves are said to cause greater losses to western stockmen than any other of the predatory animals. It is estimated that a family of wolves will destroy about $3,000 worth of stock per annum, and that one able-bodied individual costs the grazing industry $600 a season. The wolves are of two classes, the smaller prairie wolves or coyotes, and the larger gray, black or timber wolves, called "lobos." These latter are the great stock-destroyers against which the campaign of the rangers has been waged. The methods of hunting wolves in the west vary. On the plains wolves are sometimes hunted with dogs and horses, but this way is considered expensive and often dangerous. This sport is described by Roosevelt in his earlier hunting books. On national forests the rangers either set out poison or baited steel traps or, by watching trails and hiding near a wolf's den, are able to shoot one or both of the old wolves when they return from foraging. In no other way, according to the forest service, can the number of wolves be kept down so well as by finding their dens and destroying the young. The skins of the predatory animals killed by the rangers are either kept as souvenirs or sold for a price or for bounty. Wolf skins in the west are said to bring from $4 to $6 for robes and rugs; a mountain lion skin, $10 to $20; and a bear skin, anywhere from $20 to $150, according to size and species. In addi-

tion to this there are bounties on bear, lions and wolves in most of the western stock states. Wyoming, in ten years, has paid out, it is said, over $65,000 in bounties on wolves alone and $95,000 more on coyotes and mountain lions. Through his activity against these pests, the forest ranger, it is said, has saved the stockmen many thousands of dollars during the year, while the protection to game animals, such as deer, elk and antelope, is of almost equal importance.

With the middle of September the fire season on the national forests has come practically to an end with less damage than ever recorded. There is always some danger from carelessness of campers or of settlers burning brush and clearing land, but the real danger season extends only from the middle of June until the middle of September. Forest officers throughout the west are congratulating themselves on a season so markedly free from heavy losses. They feel that the immunity from loss has been due to two principal causes, partly to a favorable season, but largely to a much better organization for fire prevention than has been attained heretofore. The effectiveness of the organization is shown particularly by the fact that while there were in all approximately 2,260 fires, as against 2,470 last year, yet the area burned so far this year is only about 60,000 acres as against 230,000 acres in 1912, and 780,000 in 1911. The various causes of fires have not changed greatly in their relative proportions. Railroads and lightning head the list, with campers next. There has been, however, a marked decrease in the number of fires caused by burning brush, which, according to the forest officers, indicates a closer cooperation with the settlers in and near the forests and with timberland owners in fire prevention and control. It is still true, nevertheless, that a large proportion of all fires started are due to human agencies and may generally be charged against carelessness. Fires caused by lightning are of course not preventable, but the system of lookouts by which they may be detected immediately after being set is greatly lessening the loss from this source.

UNIVERSITY AND EDUCATIONAL NEWS

The Harvard Medical School has received $50,000 from the estate of George S. Hyde.

The Flora Stone Mather Memorial Building of the College for Women of Western Reserve University was formally dedicated on September 30. The building is the gift of Mr. Samuel Mather and his children and is a memorial to Mrs. Mather, daughter of Amasa Stone, the refounder of Adelbert College, and the sister of Adelbert Stone, for whom Adelbert College is named. Mr. Mather has built the building, equipped it completely throughout, and has added to the gift the sum of $50,000, as an endowment. The Flora Stone Mather Memorial Dormitory, the gift of the alumnæ of the College for Women, will be built upon land situated south of the gymnasium. Immediately following the services at the new memorial building the land upon which the memorial dormitory is to be built was dedicated.

The College of Agriculture and Mechanic Arts, Mayaguez, Porto Rico, is this year offering an apprentice course in general agriculture. The plans for the course were approved at the April meeting of the board of trustees. The dominant feature of the course is that each student is employed eight hours per day in ordinary manual labor on the farm. From one to two hours are devoted to special class instruction. The work done by these students will be the ordinary manual labor of the farm, except that the work will be diversified so as to give each student as broad and varied experience as is possible.

Dr. John Casper Branner, professor of geology, was installed as president of Stanford University on October 1.

At the University of Illinois the following appointments have been made: L. H. Provine, superintendent of construction with the Stone and Webster Engineering Corporation at Seattle, professor of architectural engineering; L. A. Harding, professor and head of the de-

partment of mechanical engineering of the Pennsylvania State College and, during the past year, consulting engineer in New York City, professor of experimental mechanical engineering; A. C. Willard, sanitary and heating engineer of the United States War Department, assistant professor of heating and ventilation; E. A. Holbrook, professor of mining engineering and metallurgy at the Nova Scotia Technical College, Halifax, assistant professor of mining engineering; J. I. Parcel, assistant professor of structural engineering at the University of Minnesota, assistant professor of structural engineering; W. M. Wilson, chief designer with the Strauss Bascule Bridge Company of Chicago, assistant professor of structural engineering; P. S. Biegler, professor of electrical engineering in the University of Montana, associate in electrical engineering; S. O. Andrus, field assistant of the U. S. and State Geological Surveys and of the department of mining engineering, associate in mining engineering, and A. R. Knight, instructor in electrical engineering at the University of Pennsylvania, instructor in electrical engineering.

THE faculty of the College of Agriculture and Mechanic Arts of Porto Rico has changes this year as follows: Mr. D. T. Griswold, animal husbandryman, has resigned. His present address is College Station, Texas. The following are additions to the faculty: Professor Higgins, horticulture; Dr. Fredholm, agronomy; Professor Ham, manual training; Professor MacMillan, manual training; Professor Stafford, mathematics; Miss Baco, mathematics.

MR. FRED D. FROMME, a graduate of the South Dakota State College, and for the last two years a student and assistant at Columbia University, has become assistant in the botanical department of the Indiana Experiment Station. Mr. H. C. Travelbee, a graduate of Purdue University, has also become assistant in the same department. The two positions were vacated in July by Dr. F. D. Kern and Mr. J. B. Demaree, who are now at the Pennsylvania State College.

DR. FANNY COOK GATES, formerly professor of physics at Goucher College, Baltimore, has been appointed dean of women at Grinnell College, Iowa, with a full professorship in physics.

DR. FRANK DUNN KERN has been elected professor of botany at the Pennsylvania State College.

THE following new appointments have been made at the University of Pittsburgh for the coming year: *College:* John M. Mecklin, Ph.D., Leipzig, formerly professor of philosophy at Lafayette College, profesor of philosophy; W. Paul Webber, Ph.D., University of Cincinnati, formerly professor of mathematics at Bethany College, instructor in mathematics; Marks Neidle, Ph.D., Columbia University, formerly instructor in chemistry at Erin Preparatory School, instructor in analytical and physical chemistry; Emmett F. Hitch, Ph.D., Cornell University, formerly instructor in chemistry at Cornell University, assistant professor of organic and technical chemistry. *School of Engineering:* George W. Case, Cornell University, formerly assistant professor of sanitary engineering at Purdue University, assistant professor of sanitary engineering. *School of Education:* Thomas J. Kirby, Columbia University, formerly supervisor of industrial schools, N. Y., professor of elementary education. *School of Medicine:* J. D. Heard, professor of medicine; X. O. Werder, professor of gynecology; J. McMeans, instructor in clinical pathology; Miss M. E. Bothwell, research assistant; Chris. Gardner, assistant demonstrator in anatomy.

DR. CHARLES CROWTHER has been appointed professor of agricultural chemistry in the University of Leeds, and will have charge of the experiments in animal nutrition.

PROFESSOR E. W. MACBRIDE, F.R.S., has been appointed successor to the late Professor Adam Sedgwick in the chair of zoology at the Imperial College of Science, South Kensington.

DR. ALEXANDER TORNQUIST, of Königsberg, has been appointed professor of geology at Leipzig.

DISCUSSION AND CORRESPONDENCE

THE PELYCOSAURIAN MANDIBLE

Ten years ago I figured and described a peculiar bone in the plesiosaurian mandible, lying along the teeth on the inner side and meeting its mate in the symphysis. It was in form and position so totally unlike the coronoid bone of other reptiles that I hesitated long before calling it that. Within the past few years, however, Dr. Andrews has recognized the same bone in certain European plesiosaurs, and its identity seems assured.

Some time ago I made out with considerable confidence a similar structure in the mandible of *Dimetrodon*, from the Permian of Texas, but, in the absence of corroborative proof, I have waited till an abundance of material has confirmed beyond dispute the presence of a bone in the mandible lying along the teeth and reaching nearly to the symphysis. It is narrow and rather loosely attached to the dentary, so much so that it is usually macerated away and lost. It lies along the alveolar border, beginning in an acute point opposite the middle of the third tooth, and extends apparently quite to the end of the tooth series. For most of its extent it is bordered below by the splenial, which diverges from it in front opposite the posterior end of the symphysis to enclose a V-shaped tongue of the dentary. It lies closely applied to the bases of the teeth, covering over the alveolar pits for the growth of new teeth. It apparently ends below the last tooth by a narrow end, but it is not improbable that it is very narrowly continuous with the true coronoid, and if so is quite identical with the structure in the plesiosaurs. The true coronoid lies at the summit of the coronoid eminence, extending about two inches back of the teeth. It is covered on the outer side by the dentary, and is inserted in a pit in the surangular; it is usually lost in specimens of *Dimetrodon*. If it is continuous with the alveolar bone, as it seems to be, the connection must be very narrow. I doubt not that it is homologous with the bone called epicoronoid by Watson in the Stegocephalia, even as the alveolar bone is homologous with his so-called coronoid.

The splenial, hitherto undescribed in the Pelycosauria, is a large element lying along the lower side of the mandible, visible from the outer side and entering extensively into the symphysis. As I have previously stated, and as reaffirmed by Watson, this symphysial union of the splenial is characteristic of all primitive reptiles, and evidently also, of all primitive amphibians. To nearly as far as its middle the splenial is bordered above on the inner side by the alveolar bone already described. Back of its middle it is separated from that bone by the slender prolongation of the prearticular, precisely as in the plesiosaurs.

This resemblance of the structure of the mandible in the pelycosaurs with that of the plesiosaurs has an important bearing on any theory of the phylogeny of the latter group. They could not have originated from any forms in which the coronoid had been reduced to the condition in all modern reptiles.

Full descriptions and figures of the mandible, not only of *Dimetrodon*, but also of various other Permian reptiles and amphibians will be published within a year.

S. W. Williston

University of Chicago,
August 25, 1913

THE DISTANCE HOUSE FLIES, BLUE BOTTLES AND STABLE FLIES MAY TRAVEL OVER WATER

Little evidence exists as to how far stable and blue bottle flies ordinarily travel to or from their feeding and breeding places. House flies, it is claimed, seldom stray over 500 yards from their breeding places; but some English observations prove that they may go over a mile from an infested dump to the nearest village.

In connection with the Cleveland Anti Fly Campaign, urgent requests were sent in to Dr. Jean Dawson for some means of relief from the plague of flies on the cribs of the water works, situated a mile and a quarter, five miles and six miles out in Lake Erie north of the city. Being in Cleveland for a

few days, at the request of Dr. Dawson and Mr. Vandusen, of the water works department, I visited the three cribs. The department launch left the harbor about ten o'clock of the morning of August 21, steaming directly to the nearest crib, a mile and a quarter out. Two house flies came out with the launch. A light breeze was blowing from the south, possibly six to eight miles an hour, and it carried the intensely acrid, sulphurous smoke of the city out over the lake. For nearly a mile out this smoke was so strong that it made my eyes smart and run tears, and quite possibly this low sheet of smoke may have had something to do with driving the flies out of the harbor. I found this first crib swarming with flies. In a lot caught at random I counted 41 house flies, 9 stable flies and 4 blue bottles.

From this crib we steamed out to the six-mile crib. Here the flies were even more numerous than on the first crib or even anywhere about the docks. My catch here was 10 house flies, 22 stable flies and 1 blue bottle. Possibly twenty stable flies followed us into the launch and over to the five-mile crib. My catch here was from a trap baited with sugar and water with a few drops of vinegar added: 4 house flies, 25 stable flies and 12 blue bottles.

Two crib tenders live on each crib, but there are no animals and there is absolutely nothing in which flies of any kind could breed. All garbage and waste matters are dumped immediately into the lake or are put into a tight incinerator and burned daily. Lake steamers pass within about half a mile of the cribs, but none of the men had ever noticed any evidence of flies coming from them. All the crib tenders maintain that a south wind brings a cloud of flies from the city and that a north wind carries them away. No smaller boats were anywhere near the cribs that day and seldom come near them.

The only explanation for the above facts seems to be that the flies are blown at least six miles off shore, and that they gather on the cribs as temporary resting places. Attraction of any other sort can not be a strong factor: else they would remain on shore, attracted by the animals and men along the docks and the much richer food supply. While not entirely conclusive, the evidence seems strongly to support the theory that flies of the above kinds are able to travel much farther than is commonly supposed.

All the flies in the crib appeared to be ravenously hungry and it will not be difficult to trap the house and blue bottle flies as fast as they come. The stable flies bite most viciously, but they, too, enter the traps in numbers, and it is quite probable that all the flies on the cribs can be killed most easily with formalin bottles, 2.5 per cent. in a milk or beer or sugar and vinegar mixture, whichever may prove most attractive to them.

C. F. HODGE

THE WORD "FUNGUS"

TO THE EDITOR OF SCIENCE: He is a brave man who openly throws stones at another man's domicile, even if he justify the act as altruistic, knowing the proverbial danger incurred. Certainly he should not be surprised by some return.

In SCIENCE of September 5 Dr. Dabney has justly taken exception to the use of the common expression "quite a few." But he has erred in calling it "slangy," "a malevolent fungus growth," or "a sort of fad." It is simply a colloquial term in certain parts of the country, and occasionally slips into dignified writing, as do other indefensible phrases. But they are not becoming established, as Dr. Dabney implies; the tendency is quite the reverse. When all scientific men shall have been recruited from the ranks of the learned, such unpleasant evidences of the survival of youthful derelictions of speech will have disappeared.

Having taken notice of Dr. Dabney's fling, I offer one in return. One must be doubly surprised to notice that in a criticism of a colleague regarding "good English," there occurs a lapse in "good grammar." What justification is there for the usage "fungus growth?" Possibly the phraseology is in recognition of the increasing demand for hyphenated substantives, with the hyphen dropped out. Or

the adjective *fungous* may have been intended, with the *o* accidentally omitted. Or could it be that the much abused word *fungoid* would have met the author's requirement? The use of words from the sciences demands caution from the general writer, but in a scientific journal there should be no lapse, certainly none from the pen of a critic. The word *fungus* with its derivatives is too often misused.

J. C. Arthur
Purdue University,
Lafayette, Ind.

QUOTATIONS

The American University from Two Points of View

The finest thing which civilization has yet produced is a great American university upon a private foundation. A company of gentlemen associate themselves and assume the obligation of providing the means for, and the organization of, an institution for the highest culture, not only without any pecuniary compensation to themselves, but giving freely of their time, effort and substance, and securing, in their aid, the countenance and contributions of their friends and fellow citizens, and a body of scholars, selected by this original association, who, sacrificing at the outset the prospect of worldly gain, devote themselves zealously and enthusiastically to the discovery of truth and its dissemination and to the making of character—such, in brief outline, is this great product of human evolution. No other nation on the earth has brought the like of it forth. It is the peculiar offspring of American conscience and American liberty. To have had an honorable part in the creation of such an institution is a privilege of the highest order and obligates the happy participant to render to his fellowmen an account of his experiences.—Dean John W. Burgess in the *Columbia University Quarterly* for September.

In America there are three sexes—men, women and professors. It is the saying of European scholars looking from those self-governing democracies, their universities, upon ours. They see ours ruled without the consent of the governed through presidential autocrats by boards of non-scholar trustees—not a part of the world of learning, but superimposed upon it. The American professor has the status of an employee subject to dismissal without trial by men not his colleagues.

The universities of Germany, the older universities of England and Scotland respect and trust and leave free the individual. Their organization gives them the right to regard themselves as provinces of the republic of letters. The overlorded universities of America have no such right.

For a couple of centuries American professors have submitted to a system which gives most of them little control over their own lives, small power to defend any truth which has powerful enemies, no part in shaping the policies of the institutions in which they teach. Hence the pitiable figure of the American scholar to whom Emerson, Emersonically oblivious of such little matters as despotic college government, held up a high ideal of independent manhood.

The position of her scholars under the thumb of business men and capitalists who control the university purse is enough to account for the fact that America is intellectually second rate. Unless content to remain so Americans have got to think down to bedrock about university government and do what thought demands.

Feeling that something is wrong, we have begun to examine the life of our universities, but no general attention has centered as yet upon their inherited, undemocratic system of control which is bearing the fruit of timidity and subservience among those twenty-three thousand men and five thousand women whose social function is to create and transmit American thought.—George Cram in the *Forum* for October.

SCIENTIFIC BOOKS

Determination of Time, Longitude, Latitude and Azimuth. Fifth Edition. By William Bowie. Special Publication No. 14, U. S.

Coast and Geodetic Survey. Washington, Government Printing Office. 1913.

It is the purpose of the reviewer to discuss Parts I. and II. only—the parts relating to the determination of time and longitude.

The reason for the appearance of the volume is twofold: first, the fourth edition, by Professor John F. Hayford, at the time inspector of geodetic work, has become exhausted; and secondly, so much that is new has developed in the interim, and so much of the old has become changed or entirely discarded, that it has been thought advisable, even though much of the old material may be found scattered through other publications, to issue still another volume, one which shall be in itself complete and thoroughly accordant with present practise. So great is the demand for this valuable manual that the new edition has already nearly given out, and it has consequently been found necessary to order the printing of an additional thousand copies.

The self-registering transit micrometer, introduced by Repsold a quarter century ago, and the principle soon after adopted in Europe of reversing the transit instrument during the observation of each star, have almost revolutionized the methods of longitude determinations. Their advantage is that they afford additional strides forward in the direction of eliminating constant and systematic errors by skilful observational manipulation rather than by applying corrections in the course of the computation. Reversal during the transit of each star eliminates collimation, inequality of pivots, irregularity and other errors of the transit micrometer screw (or, if a fixed reticle be employed, the thread intervals), and, in the case of the broken-back telescope, bisection error and flexure. With regard to the micrometer, though claim has been made that its use leads to a higher degree of precision, its chief value lies in that it almost annihilates the observer's personal equation. As the instrumental and personal equations are thus so greatly reduced, further approach is rendered possible towards the ideal arrangement of reducing the observational errors exclusively to the accidental type. These two innovations have accordingly been attended with so great success that, employed originally in the field, they have found their way even into the fixed observatory.

There the right-ascension micrometer has come to stay. Whether the ponderable telescopes of the fixed observatory can be adapted to quick reversal, however, remains yet to be seen. At Kiel and at Bergedorf they are employing transit circles designed and built with this purpose in view, but the onlooker during the operation of reversal instinctively fears for the safety of the instrument. Experiments are still under way. Speedy reversal with the portable transit, on the other hand, was long ago effected by both the Germans and the French, the latter developing the straight telescope with diagonal eye-piece, the former the broken back.

Ever alert as the Coast and Geodetic Survey authorities are for any device bearing the impress of improvement, they have stamped their mark of approval upon both these innovations. Though they have not purchased or made any astronomic instruments for time observations since the appearance of the fourth edition of their manual, they have recently ordered two telescopes of the broken type, reversible on each star, such as have "been used with marked success by other countries," and illustrated in Plate 2. The right-ascension micrometer they welcomed a decade back. Skilfully designed by the chief of the instrument division, Mr. E. G. Fischer, and tested in a thorough experimental and theoretical investigation by Professor Hayford,[1] the micrometer has since proved of such worth that the effect of its introduction may be traced throughout the new edition.

When the chronographic method of star registration was introduced in the middle of the last century—and it will be recalled what a prominent part the Coast Survey played in the introduction—astronomers fondly hoped to eliminate by its means that most troublesome of "constant" errors, personal equation. That it greatly reduced the magnitude of this

[1] Appendix No. 8, Report of the Superintendent for 1904, "A Test of a Transit Micrometer."

equation as obtained by the method of the eye and ear is well established. The same fond hopes lay at the basis of introducing the "impersonal" micrometer; and again there has been a great reduction in personal equation. The evidence in favor of annihilation, however, is inconclusive. Though many astronomers have succeeded in reducing the equation to practically within the limits of accidental error, and some have made so bold as to affirm that the equation has entirely disappeared, there yet remain other astronomers who have not been able to verify these conclusions—witness the experiences at Ottawa. As likely as not, history will repeat itself.

Even if personal equation has not been annihilated, nevertheless, astronomers now possess an advantage that formerly was not theirs; and that is, that with present facilities it is possible entirely to dissipate the effect of personal equation in longitude determinations. For the *variation* of personal equation, generally conceded to be the chief source of longitude error, may, now that the personal equation itself has become so much lessened, be looked upon as lessened to a corresponding degree, which makes it negligible; and the small residual amount of personal equation left in the observations by the right-ascension micrometer may be made to disappear through exchange of observers.

It is only in the finest class of longitude work that the precaution of exchanging observers is deemed necessary. For ordinary geodetic purposes, since personal equation has become so small as to be termed negligible, this precaution is believed to be needless. The introduction of the transit micrometer has consequently led to radical changes in the methods and program of survey longitude operations. "The program of longitude observations was formerly designed to eliminate the personal equation" (p. 79); and variation of personal equation is a bugbear no longer to be feared. The influence on the time and expense connected with longitude work (p. 94) may be estimated from the fact that it has been found possible, in accordance with Professor Hayford's prediction of 1904, without loss of accuracy, to reduce the original program of ten nights' observing to three or four. It should be noted, however, that even with the method of the key, "a reduction of the number of nights per station to six, or even four, would result in but slight decrease in accuracy" (p. 94).

Before leaving the topic of personal equation it may be well to call attention to another form of this equation, the bisection error. On page 90 the writer believes that for ordinary geodetic purposes this is too small to be considered. This may or may not be true; and it may make a difference whether a single or a double thread be employed. Contradictory evidence may be found in "A Test of a Transit Micrometer," above cited (p. 472), and "Report of the Chief Astronomer," Ottawa, 1909 (pp. 576 et seq.). By reversal during the transit of each star, as already mentioned, the bisection error is automatically eliminated from observations made with the broken-back telescope. With the straight telescope, this elimination may be effected, not from each individual star, but from the clock correction, by a suitable selection of stars north and south of the zenith.

Returning to the survey observing program, another innovation involves the sets of stars comprising a time determination for longitude. The former custom of requiring generally four half-sets is still retained; but the nature of the sets is greatly changed. Where formerly it was customary to observe four clock stars and one azimuth star to each half-set, the clock stars chosen with balanced A factors, the practise now is to eliminate the azimuth star entirely, and to replace it by two additional clock stars. As the interval of time required to observe each star is less than by the method of the key, the total time employed is not greater than before. The argument is, that as the azimuth of the instrument, owing to the balancing of the A factors, has but little effect upon the resulting time determination, it is preferable, rather than to attempt determining this azimuth accurately with an azimuth star, to strengthen the clock correction by observing additional time stars. For

a discussion of this topic see the fourth edition, p. 295.

At latitudes higher than 50°, where it is impracticable to obtain sufficiently slowly moving zenith stars with balanced *A* factors, and where, consequently, the error in azimuth will materially affect the clock correction, the older method of observing an azimuth star is still employed. The number of stars in each half-set, however, following perhaps the practise of the Germans, is increased to six. It is a fair question, in this connection, whether this ratio of azimuth to clock stars is sufficiently large.

The time sets are so chosen, and the reversals of the instrument between half-sets so planned, as to eliminate collimation and inequality of the pivots (p. 19). Inequality and irregularity of the pivots, indeed, as the pivots have been reground and tested (p. 46), and owing to the plan of observing adopted (p. 50), is thought negligible. This is in contrast to the practise formerly in vogue. As for the collimation, if it may be depended upon to remain constant during a time set, it will be eliminated entirely. With instruments reversible on each star, as already noted, inequality of pivots and collimation are rigorously eliminated automatically by the reversal. Instead of depending upon the invariability of the instrumental constants for an hour, this dependence is necessary for but a few moments—a decided advantage. On the other hand, the possibility exists that too frequent reversal may disturb the azimuth; and as the disturbance is likely to occur between the two parts of each star observation, this is a serious matter. The French have accordingly introduced the practise of reading at sufficiently frequent intervals on a meridian mark.

It should be noted, too (p. 27), that among other advantages, reversal on each star leads to simplified computation.

"It is desirable, but not necessary" (pp. 43 and 80, sec. 4), is the comment on the requirement of the previous edition that the same stars, wherever possible, be observed at both stations of a longitude determination. It is now believed that errors of the star places are smaller than those introduced by the instrumental constants; or by the variation of those constants due to extending the observations over too long an interval; or by poor balancing of the *A* factors; or by an unwise choice of epoch for exchange of clock comparison signals (pp. 87 and 93, sec. 7). The argument upon which this reasoning is based is not conclusive; for the accidental errors of the star positions alone are taken into account, nothing being said of those classed as systematic. Yet it is probably true that great inaccuracy will not result, especially if a large proportion of the stars be observed in common at the two stations.

Not only is the publication marked by the adaptation of a new device to the old instrument, and the adoption of a new program of observing, but also by a new method of reducing the observations. The germs of this method may be found in the old edition, p. 296. The use of least squares has for the most part been done away with; the refinement, evidently, is believed to be unwarranted by the observed data. The result is a more direct and easy method of solution. To simplify the computations further, unsymmetrical threads are usually rejected (pp. 24, 79 and 80). Criteria for the rejection of other threads are laid down on p. 80. Corrections for rate (p. 24) are generally regarded as unnecessary refinement. Contrary to former practise, all stars observed at latitudes under 50° are weighted equally (pp. 79 and 80), and weights generally are taboo (p. 89).

The survey is quick to take advantage of any opportunity. When the International Geodetic Association commenced furnishing corrections for reducing the observed to the mean position of the pole, the survey began to make use of these corrections. When the *American Ephemeris and Nautical Almanac* became enabled, through the omission of the lunar distance tables, to extend its list of stars, the survey, probably having in mind also the greater ease of interpolation from the Washington meridian, assigned to that ephemeris the preference formerly held by the *Berliner Jahrbuch* (pp. 25 and 43); and from

considerations of economy it put a stop to the practise formerly permitted of computing apparent places. When, from the same cause, the *American Ephemeris* found room between its covers for tables of Polaris facilitating azimuth determinations, the survey was quick to take advantage also of these tables (p. 17).

With regard to Mr. Duvall's ingenious device for the graphical determination of the *A, B, C* factors of Mayer's formula, it may be stated that this is not the first time such a device has been put forward. Plate XII., Astronomical Observations of the U. S. Naval Observatory, Washington, 1846, with description on pp. xliv et seq., illustrates a similar solution of the same problem by Bessel's formula, the chart being adapted to the determination of $m + n \tan \delta$, and also, with the aid of an auxiliary table, of $c \sec \delta$.

The difficulty encountered in the footnote on p. 270 of the former edition has been neatly surmounted in the new.

Another novel feature is the inclusion of a treatise on time determinations with the vertical circle. It would not be surprising to find the next edition include also an account of the astrolabe. Recently developed by the French, and claimed by them to give results comparable with those obtained by the portable transit, this instrument has much to commend it. It is as portable as a theodolite, requires no firm-set pier, is easily manipulated, and the same observations employed for time may be used also for latitude.[2] On the other hand, the computations, both preliminary to and following the observations, are heavy; and the most serious obstacle encountered with this instrument, if all accounts are to be believed, would seem to be that old and familiar stumbling-block, personal equation.

From a literary standpoint the new edition is markedly improved. Where in the older volume the diction was awkward, it has here been replaced by wording more smooth and elegant. Here and there a sentence has been altered for clearness, or a phrase added to supply an idea previously left to the fruitful imagination of the reader. Where a paragraph or a sentence was superfluous, it has here been omitted. The numbering of the sections has been done away with, and more headings have been supplied for sections which properly should appear as such. It can not be said, on the other hand, that the change from words to figures when referring to numerals is a decided literary advantage; nor that all omissions have been improvements. On p. 23, for example, there might have been retained in its proper place the remark on p. 281 of the former edition, "For a discussion of this matter, see —." Among minor changes may be noted slight modifications of notation to prevent confusion, and the substitution of numerals for asterisks and daggers. The continuity is broken by continual switching from discussion of methods with the transit micrometer to those with the key, but to offset this the book is of increased value as a more complete manual.

Of the various methods for determining longitude, the ordinary telegraphic and the chronometric are treated fully. Lunar and other methods less frequently employed in the survey are merely mentioned on p. 78. Determinations by wireless telegraphy, though already employed in Europe and by the American Navy are still in the experimental stage. This will without doubt be the method of the future, and the proposed determination of the difference of longitude between the U. S. Naval Observatory and the Observatory of Paris, as well as a similar trans-Atlantic scheme under contemplation by the survey authorities for the near future, should aid greatly in the development of this method.

The publication is highly creditable to the officers of the Coast and Geodetic Survey, and the reviser and part author is to be congratulated upon maintaining so well the high standard set by his predecessors, Schott and Hayford.

David Rines

[2] See Chauvenet's "Spherical Astronomy," Vol. I., p. 280, and Claude et Driencourt's "L'Astrolabe à Prisme."

The Climate and Weather of San Diego, California. By Ford A. Carpenter, LL.D.,

Local Forecaster, United States Weather Bureau. San Diego Chamber of Commerce. 1913. Pp. xii + 118.

That a chamber of commence thinks it advisable to publish such a volume as this speaks well for the city represented. The book bears little resemblance to the ordinary "boom literature" of pushing cities, with which we are too familiar.

The book is distinctly readable and interesting. The weather phenomena of the southern California region are treated in a somewhat popular, but thoroughly scientific manner. The elements, which make up the complex called climate, are considered separately; both the conditions more or less peculiar to the region and those of more widespread occurrence are considered from the standpoint of their causes. The climate of San Diego, from the records of the Weather Bureau and its predecessor, the Signal Service, is shown by the usual tables of data and is also described in words. The record is uninterrupted from its beginning, July 1, 1849, when meteorological work was established in San Diego as a part of the duties of the post surgeon of the army; therefore the data form one of the longest records in the United States. The book is well illustrated with photographs of the region and the meteorological instruments, as well as with maps and diagrams.

This volume may well serve not only as a sample of the kind of thing which can and ought to be done by a progressive chamber of commerce or similar organization in a region climatically favored, but it is also well suited as an introduction to the whole subject of meteorology and should give a better understanding to the processes which control the weather. Both Dr. Carpenter and the city of San Diego are to be congratulated on the appearance of this volume. It is to be hoped that as interesting and accurate discussions of the climates of particular places will become the rule, instead of the exception as at present.

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NOTES ON METEOROLOGY AND CLIMATOLOGY

INTERNATIONAL METEOROLOGY

THE report of the secretary (Dr. G. Hellmann) of the meeting of the International Meteorological Committee (composed, in general, of the directors of national weather services), held in Rome, April 7–12, 1913, has recently appeared.[1]

Assistance on the question of the influence of weather on agriculture having been asked by the president of the International Institute of Agriculture, the Meteorological Committee responded by appointing a permanent commission consisting of Messrs. Angot, Börnstein, Brounow, Louis Dop, Hergesell, Palazzo and Stupart.

The recommendations of the Commission on Weather Telegraphy, which met in London in September, 1912, were adopted with but few changes. Thus on May 1, 1914, the long-desired, uniform telegraphic code throughout Europe will come into use.

The report drawn up by Messrs. Palazzo, Köppen and Lempfert showed that the mean wind velocities equivalent to the numbers of the Beaufort scale of wind force in use in different countries are widely variant. The Meteorological Committee asked for a further investigation, to consider gusts of wind as well as mean velocities for the force equivalents of the 10- or 12-point Beaufort scale.

The proposal of the International Committee for Scientific Aeronautics to have international cooperation in upper-air observations in many parts of the Arctic in 1915, during Captain Amundsen's polar expedition, was warmly supported and a small subcommittee consisting of Messrs. Hergesell, Rykatchew, Ryder and Stupart was appointed to deal with the question.

To have aerological data in convenient form for the purposes of dynamic meteorology, Professor V. Bjerknes, of Leipzig, at the meeting

[1] "Bericht über die Versammlung des internationalen meteorologischen Komitees Rom 1913," No. 260, Veröffentlichungen des Kgl. Preuss. Met. Inst. Berlin. See also *Nature*, London, Vol. 91, p. 198.

of the International Commission for Scientific Aeronautics in Vienna, May 27–June 1, 1912,[2] proposed (1) that the results of upper-air observations shall be arranged according to definite steps of pressure instead of steps of height; (2) that the heights shall be given in "dynamic meters," *i. e.*, a step corresponding with a certain difference of gravity potential, not of geometric height; (3) that pressures shall be recorded in millibars (C.G.S. units), instead of in millimeters or inches. There was so much objection against a change of units, that the Meteorological Committee resolved that, for the present at least, aerological pressure results should be published both in millimeters and in millibars. The substitution of pressure steps for linear steps was favorably passed upon, but the proposition as to "dynamic meters" was referred back to the commission at the request of its president, Dr. Hergesell, for further consideration.

On the recommendation of the radiation commission, it was resolved that specifications as to sunshine recorders be drawn up, to facilitate comparison between sunshine records in different countries.

The resolution of the Paris conference (1896), calling for the standardization of thermometer exposure, was discussed and tests of English thermometer shelters in the tropics were recommended.

A system of signals for international use was recommended by the Commission on Maritime Meteorology and Storm-warning Signals, and accepted by the Meteorological Committee with a few minor changes. Thus a substantial measure of international agreement on day and night storm-warning signals has been attained.

The next conference of the committee will come in 1915, in Holland.

EVAPORATION FROM LAKE SURFACES

In the *Meteorologische Zeitschrift* for May, 1913, Dr. J. Maurer, director of the Swiss Weather Service, gives the results of his measurements of evaporation from the surfaces of Lakes Zuger and Ägeri in northern Switzerland, December, 1911–November, 1912, inclusive. By the method used, the evaporation is the difference between the amount of water entering a lake and that flowing out, if the water-surface level remains constant. The amount entering in streams was determined as closely as possible by frequent measurements of the cross-sections and velocities of the streams flowing into the two lakes. To these the amounts of rainfall on the lake surfaces were added. The water flowing through the outlet streams was also carefully measured. With the aid of measurements of the variations in height of the lake surface as indicated on gauges for the purpose, the results from the other measurements could be checked to some extent. The totals of monthly evaporation are probably correct within 0.5 cm. The unknown amount of gain or loss of water through the lake bottom was disregarded, for, on the whole, these lakes have impervious basins and no large springs are known. Supplementary observations of the temperature of the water surface, humidity at the water surface, and of the air-temperature, wind, cloudiness, etc., were taken at selected points. In 1912, a year with a cool and rainy August and September, the measurements showed an evaporation of 775 mm. from Zuger Lake (417 m. above sea level, area 34 sq. km.) and 740 mm. from Ägeri Lake (727 m. above sea level, area 7 sq. km.). In a year with a normal summer, the annual evaporation would probably exceed 900 mm. These interesting results are the first of their kind yet published, and bid fair to lead the way for other similar measurements on lakes and reservoirs elsewhere.

VOLCANOES AND CLIMATE

The solar radiation observations of Messrs. C. G. Abbot and F. E. Fowle[3] and Professor H. H. Kimball[4] show that the Katmai volcanic dust cloud in the atmosphere in the summer of 1912 in the northern hemisphere, so increased diffuse reflection into space and absorption of heat in the upper atmosphere, that the normal

[2] See *Nature*, London, Vol. 90, p. 110.

[3] "Volcanoes and Climate," Smithsonian Misc. Coll., Vol. 60, No. 29.

[4] *Mt. Weather Bull.*, Vol. V., Part 5.

amount of solar radiation received at the earth's surface was decreased by about 10 per cent. Observations of terrestrial radiation made at the same time by Mr. A. K. Ångström, showed that the presence of the dust likewise hindered terrestrial radiation, but not to such an extent as the solar radiation (of shorter wave-length). The net result of these opposite tendencies, however, seems to have been a decrease of heat available to warm the lower atmospheres. Temperature observations of high-level stations in Europe and America bear this out, showing a marked decrease of temperature with the beginning of the volcanic dust cloud at the end of June.

Other periods of marked decrease in the solar radiation received as observed during the last thirty years were the period 1883–1885 following the Krakatoa eruption; 1888–1894 after the great eruptions of Bandai-San, Mayon and other volcanoes; and the period 1902–1904 following the tremendous eruptions of Santa Maria and Colima.

In comparing Abbot's and Fowle's composite curve of Wolfer's sunspot numbers and Kimball's solar-radiation departures, with the mean departures of maximum temperature of 15 stations in the United States, it is interesting to note that the temperature effects of these dust-haze periods seem to explain the discrepancies in the apparent synchronism between terrestrial temperatures and the 11-year sun-spot period.

In an extra number of the *Bulletin of the Mount Weather Observatory*,[5] Professor W. J. Humphreys has discussed at length the subject "Volcanic Dust and Other Factors in the Production of Climatic Changes, and Their Possible Relation to Ice Ages." Particular attention is given to sun-spots and great volcanic eruptions as related to variations in temperature at the earth's surface since 1750. The phase of this subject concerning geological changes of climate is treated by the same author in the *Scientific American* Supplement, August 23, 1913, p. 114.

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[5] Vol. VI., Part 1, 34 pp.

DEGREES CONFERRED BY THE UNIVERSITY OF BIRMINGHAM

AT the Birmingham meeting of the British Association the university of the city conferred, as has already been noted here, the degree of doctor of laws on several of the foreign guests. In introducing them Sir Oliver Lodge, president of the association and principal of the university, spoke as follows:

DR. ARRHENIUS: Director of the Nobel Institute for Physics and Chemistry, at Stockholm, fellow of the Swedish Academy of Sciences, and foreign member of our own Royal Society. The courageous way in which Dr. Arrhenius applied the theory of electrolytic dissociation to a quantitative study of chemical reactions has profoundly modified the trend of chemical science during the past thirty years, enlarging the scope of chemical investigation, harmonizing previously disconnected facts, and bringing an ever-increasing number of chemical phenomena within the range of quantitative and mathematical treatment. He is thus one of the most prominent of the founders of modern physical chemistry, the principles of which he has even applied, with singular success, to some of the most subtle phenomena of organic life. Recently his writings on cosmogony have aroused wide interest; terrestrial electricity and the aurora have yielded to him some of their secrets; and his speculations on worlds in the making are more than interesting and suggestive. A man of genius, and one of the founders of physical chemistry, I present for the honorary degree of doctor of laws, Svante August Arrhenius.

MADAME CURIE: The discoverer of radium, director of the Physical Laboratory at the Sorbonne, and member of the Imperial Academy of Sciences at Cracow. All the world knows how Madame Curie (coming from Warsaw as Marie Sklodowska to work in Paris), inspired by the spontaneous radioactivity newly discovered by Becquerel, began in 1896 a metrical examination of the radioactivity of minerals of all kinds; and how, when a uranium residue showed a value larger than could have been expected from its uranium content, she, with exemplary skill and perseverance, worked down some tons of this

material (given her by the Austrian government on the instigation of Professor Suess), chemically dividing it and retaining always the more radio-active portion, until she obtained evidence first of a new element which she christened polonium, in memory of her own country, and then after months of labor succeeded in isolating a few grains of the other and more permanent substance now so famous —a substance which not only exhibits physical energy in a new form, but is likely to be of service to suffering humanity. Of the metallic base of this substance she determined the atomic weight, finding a place for it in Mendeléeff's series; and with the aid of her husband, whose lamentable death was so great a blow to science, she proceeded to discover many of its singular properties, some of them so extraordinary as to rivet the attention of the world. Subsequent workers engaged in the determination of numbers belonging to either of her special elements, radium and polonium, have sought her advice, and it has proved of the utmost value. I have now the honor of presenting for our honorary degree the greatest woman of science of all time, Marie Sklodowska Curie.

Professor Keibel: The professor of anatomy in the University of Freiburg is the leading authority on the development of man and the embryology of vertebrates. He originated the international standards used in estimating embryological data, and through his classical work on comparative development he has reformed anatomical teaching by the infusion of developmental ideas. His important contributions to anatomical knowledge and method are widely known and highly esteemed, but nowhere more heartily and cordially than in the anatomical department of this university. Held in affectionate esteem by his colleagues, and directing one of the largest schools of anatomy in Germany, this eminent embryologist has been invited to receive our honorary degree, and I present to you Franz Karl Julius Keibel.

Professor H. A. Lorentz: To the great school of mathematical physicists of the last and present centuries we in England have proudly contributed even more than our share; but we recognize in the professor of physics in the University of Leyden a contemporary worker worthy to rank with our greatest. Professor Lorentz has extended the work of Clerk Maxwell into the recently explored region of electrons, and has developed in the molecular direction the Maxwellian theory of electrodynamics. He is a chief authority on the behavior of material bodies moving through the ether of space, and he has adopted and reduced to order many of the progeny resulting from the fertile marriage of electricity and light. A specially interesting magneto-optic phenomenon, experimentally discovered by his countryman, Zeeman, of Amsterdam, received at his hands its brilliant and satisfying interpretation; an interpretation clinched by predictions of what, on the electric theory of radiation, ought additionally to be observed—predictions which were speedily verified. The Zeeman phenomenon thus interpreted not only gives information as to the intimate structure of various elemental atoms, but, in the hands of the great American astronomers, has shown that sun-spots are electric cyclones of high magnetic power, and is likely further to contribute to our knowledge of solar and stellar constitution. As a great authority on electron theory, and one whose name will forever be associated with the now nascent electrical theory of matter, I present to you the distinguished mathematical physicist, Hendrik Antoon Lorentz.

Professor R. W. Wood: The professor of experimental physics in the John Hopkins University of Baltimore is a prolific experimentalist, and one to whose researches in physical optics modern science is greatly indebted. By ingenious use of little-known properties of light, he has explored the structure of molecules, applying the principle of resonance to determine their natural electronic period of vibration. He has, in fact, discovered a new type of spectra in the fluorescent resonance of metallic vapors. What more he has done, in connection with the anomalous absorption of sodium vapor with specially designed diffraction gratings, and with the application of monochromatic photography to the geology of the moon, it were long to tell; among other

things, he anticipated and realized the attainment of regular reflection from a sufficiently dense absorbing vapor; while to the public in America he is known as the inventor of a practical method of thawing frozen pipes by an electric current. The idea of a gigantic telescope in the form of a sunk well, with a revolving pool of mercury at its base to constitute a truly parabolic mirror, may not be a new one, but Professor Wood has taken it out of the region of the chimerical and shown that it is possible, even if not practically useful. We in this country have reason to envy the splendid resources which the munificence of citizens in America, and of governments elsewhere, places at the disposal of scientific explorers, and we honor and admire the use which is being made of those resources in every branch of science. As one of the most brilliant experimental physicists of the world, I present for our honorary degree Robert Williams Wood.

THE NEW INTERNATIONAL DIAMOND CARAT OF 200 MILLIGRAMS

THE importance of having uniform weights, and the great practical disadvantages resulting from the international use of a perplexing variety of standards, have long made themselves felt in the diamond market. This subject has just been very fully treated in a paper read before the American Institute of Mining Engineers, at the New York meeting, February, 1913, and at the Butte meeting, August, 1913.[1]

Those unfamiliar with the system of weights employed by diamond-dealers can scarcely appreciate the confusion that has existed, and the necessity for complicated calculations thereby entailed. This state of things will be best illustrated by giving here the equivalents in milligrams and troy grains of the principal standard carats as used in various trade centers:

	Milligrams	Grains Troy
Turin	213.5	3.29480
Persia	209.5	2.23307
Venice	207.1	3.19603
Austro-Hungary	206.1	3.18060
France (old)	205.9	3.17752
France (later)	205.5	3.17135
France (modern)	205.0	3.16363
Portugal	205.8	3.17597
Frankfort and Hamburg	205.8	3.17597
Germany	205.5	3.17135
East Indies	205.5	3.17135
England and Brit. India	205.3	3.16826
Belgium (Antwerp)	205.3	3.16826
Russia	205.1	3.16517
Holland	205.1	3.16517
Turkey	200.5	3.09418
Spain	199.9	3.08492
Java and Borneo	196.9	3.03862
Florence	196.5	3.03245
Arabia	194.4	3.00004
Brazil	192.2	2.96610
Egypt	191.7	2.95838
Bologna	188.6	2.91054
Internat. Carat, year 1875	205.0	3.16363
New International Carat	200.0	3.08647

A glance over this table will serve to show the crying need for the establishment of a uniform and rational standard, and a preliminary step in this direction was taken by the Parisian jewelers in 1877, when they adopted a carat of exactly 205 milligrams. However, such a carat could never become an integral part of the metric system, and as early as 1893 the writer suggested in a paper read at Chicago before the International Congress of Weights and Measures, held in connection with the World's Columbian Exposition, that a carat of exactly 200 milligrams should be recognized as the standard carat weight. Many years, however, elapsed before there was any definite prospect that this idea would be realized. The fact that in the early part of 1905 the German imperial government refused to recognize the carat then used in Germany as a standard weight, when requested so to do by the German Federation of Jewelers, because such recognition would be a violation of the laws prescribing the exclusive use of the metric system, is said to have powerfully

[1] "The New International Metric Diamond Carat of 200 Milligrams (Adopted July 1, 1913, in the United States)," by George Frederick Kunz, New York, N. Y., author's edition, 21 pp. (pp. 1225–1245 of the *Trans. of the Soc. of Min. Eng.*).

stimulated French endeavors for the reform of the carat by bringing it within the scope of the metric system.

The most effective worker in this direction was M. C. E. Guillaume, director of the Bureau International des Poids et Mesures at Sèvres, who urged the adoption of a carat of 200 milligrams before the International Congress in April, 1905. In January of the succeeding year, the Chambre Syndicale de la Bijouterie, Joaillerie et Orfèvrerie of Paris passed a resolution favoring the adoption of the metric carat, and in August of the same year the German federation of gem-dealers and jewelers urged its general adoption. The movement thus initiated soon spread, and by 1908 Spain had given the new carat a definite legal status, to be followed in 1909 by Japan and Switzerland. The adhesion of Italy, Bulgaria, Denmark and Norway followed in 1910, that of Holland, Portugal, Roumania and Sweden in 1911. Although it was not until 1912 that it became the legal standard in France and Germany, the law providing for its institution in the former land was passed June 22, 1909.

As in the case of all efforts to introduce metric weights or measures, the advantages of the new metric carat only very gradually became apparent in England and the United States. However, its official adoption by our Treasury Department, on July 1, 1913, as the standard for customs purposes, definitely stamps it with the seal of official acceptation here.

Belgium has already provided for the use of the new carat and England is expected to fall into line before long, so that by next year it is confidently believed there will be but one standard weight for diamonds, precious stones and pearls, the metric carat of 200 milligrams.

The paper gives a simple and easy method for converting the old carats of 205 milligrams into the new ones of 200 milligrams, and also offers many interesting details as to the history of the carat and the origin of decimal notation, the first known examples of the latter being found in a translation, published by Leonardo of Pisa in 1202, of a work by the ninth-century Arabian mathematician, Al-Khouârazmi. The first use of the decimal point is stated to occur in the arithmetic of Frances Pellos, printed at Turin in 1492.

There can be little doubt that the adoption of the metric carat in the United States will do much to favor the cause of the metric system generally in this country, as not only the thousands of jewellers but also the millions of people who buy jewelry will now learn, most of them for the first time, what a kilogram, a gram and a milligram are, when they are told that a carat equals 200 milligrams; five carats, one gram, and 5,000 carats (or 20,000 pearl grains), one kilogram.

Some additional particulars may be added from advance sheets of M. Guillaume's report to the International Conference of Weights and Measures. The Argentine Republic, Peru and Servia are all disposed to accept the new carat. In Belgium the law promulgated March 10, 1913, embraces the following article:

> In transactions concerning diamonds, pearls and precious stones, the denomination "metric carat" can be given to the weight of 200 milligrams, in derogation of articles 1 and 3 of the law of October 1, 1855.

The employment of the word "carat" to designate any other weight is prohibited.

In regard to eventual results M. Guillaume believes that the day will come when the commerce in precious stones will be confined to the employment of the ordinary metric unities; the establishment of the carat as a fiftieth part of a grain will then have constituted a stage in this definite reform, and one greatly favoring it.

George F. Kunz

SPECIAL ARTICLES

THE MECHANISM OF FERTILIZATION

In previous papers[1] I have described the secretion of a substance by the ova of the sea-

[1] Science, N. S., Vol. 36, pp. 527–530, October, 1912, and *Journ. Exp. Zool.*, Vol. 14, No. 4, pp. 515–574, May, 1913.

urchin, *Arbacia,* in sea water, which causes agglutination of the sperm of the same species. The eggs of *Nereis* also secrete a substance having a similar effect upon its sperm. I therefore named these substances sperm-iso-agglutinins. During the present summer I have ascertained that in the case of *Arbacia,* and presumably also of *Nereis,* the agglutinating substance is a necessary link in the fertilization process and that it acts in the manner of an amboceptor, having one side-chain for certain receptors in the sperm and another for certain receptors in the egg. As this substance represents, presumably, a new class of substances, analogous in some respects to cytolysins, and as the term agglutinin defines only its action on sperm suspensions, I have decided to name it fertilizin.

My main purpose this summer was to study the rôle of the *Arbacia* fertilizin in the fertilization of the ovum.

1. *The Spermophile Side-chain.*—The first need in such a study was to develop a quantitative method of investigation, and this was done for *Arbacia* as follows: The agglutinative reaction of the sperm in the presence of this substance is, as noted in previous studies, reversible, and the intensity and duration of the reaction is a factor of concentration of the substance. The entire reaction is so characteristic that it was possible to arrive at a unit by noting the dilution at which the least unmistakable reaction was given. This was fixed at about a five- or six-second reaction, which is counted from the time that agglutination becomes visible under a magnification of about 40 diameters until its complete reversal. The unit is so chosen that a half dilution gives no agglutination of a fresh 1 per cent. sperm suspension. It was then found that the filtrate from a suspension of 1 part eggs left for ten minutes in 2 or 3 parts sea water would stand a dilution of from 800 to 6,400 times, depending on the proportion of ripe eggs and their condition, and still give the unit reaction. Such solutions may then be rated as 800 to 6,400 agglutinating power, and it is possible, therefore, to determine the strength of any given solution. This gives us a means of determining the rate at which eggs are producing fertilizin in sea water.

Determinations with this end in view showed that the production of fertilizin by unfertilized eggs of *Arbacia* in sea water goes on for about three days and that the quantity produced as measured by dilution tests diminishes very slowly. Such tests are made by suspending a given quantity of eggs in a measured amount of sea water in a graduated tube; the eggs are then allowed to settle and the supernatant fluid poured off and kept for testing. The same amount of fresh sea water is then added and the eggs stirred up in it, allowed to settle, the supernatant fluid poured off for testing, and so on. In one series running three days in which the quantity of eggs was originally 2 c.c. and the total volume of sea water and eggs in the tube 10 c.c., 6 to 8 c.c. being poured off at each settling, thirty-four changes were made and the agglutinating strength of the supernatant fluid diminished from 100 at first to 20 at the end. Simultaneously, with this loss of agglutinating strength, two things happen: (1) the jelly surrounding the eggs undergoes a gradual solution; (2) the power of being fertilized is gradually lost.

It is obvious that the presence of fertilizin in such considerable quantities in so long a series of washings shows either (1) that solution of the jelly liberates fertilizin, or else (2) that the eggs secrete more fertilizin each time they are washed. Both factors enter into the case inasmuch as (1) eggs killed by heat (60° C.) will stand 14 or 15 such washings, but with more rapid decline of agglutinating power than the living eggs. The jelly is gradually dissolved away in this case also, and is presumably the only possible source of the agglutinating substance. (2) Eggs deprived of jelly by shaking continue to produce the fertilizin as long as eggs with jelly, though in smaller quantities at first, and they are equally capable of fertilization.

The fertilizin is therefore present in large quantities in the jelly, which is indeed saturated with the substance, but the eggs continue to produce it as long as they remain alive and unfertilized. When the eggs are

fertilized the production of this substance suddenly ceases absolutely.

The total disappearance of fertilizin from fertilized eggs can not be demonstrated unless the fertilizin-saturated jelly with which the eggs are surrounded be first removed. This is very easily done after membrane formation by six vigorous shakes of the eggs in a half-filled test tube. Three or four washings then are sufficient to remove the remains of the jelly, and the naked eggs no longer produce the substance.

Such disappearance may be due either to complete discharge from the egg, or to fixation of all that remains by union with some substance contained in the egg itself. That such a substance—anti-fertilizin—exists in the egg can be shown by a simple test-tube experiment: If eggs deprived of jelly are washed 34 times in sea water during three days, they are so exhausted that they produce but little fertilizin; the supernatant fluid may be charged only to the extent of 2 to 10 units. The eggs are now on the point of breaking up. If they are then vigorously shaken and broken up so that the fluid becomes colored with the red pigment of the eggs, it will be found that agglutinating power has entirely disappeared from the solution. The fertilizin present has been neutralized. The same phenomenon may be demonstrated also by treating eggs, deprived of jelly in order to get rid of excess of fertilizin, with distilled water which lakes the eggs and extracts the anti-fertilizin.

It is probable, therefore, that any excess of fertilizin remaining in the egg not bound to the sperm is neutralized by this combination, and polyspermy is thereby prevented.

We have noted (1) the secretion by unfertilized eggs in sea water of a sperm agglutinating substance, fertilizin; (2) the extreme avidity of the sperm for it as shown by dilution tests; (3) in my previous papers the fixation of this substance in sperm-suspensions of the same species (quantitative measurements will be given in the complete paper); (4) the sudden cessation of fertilizin production by fertilized eggs; (5) the existence of an anti-fertilizin in the egg; (6) in eggs submitted to a series of washings decrease of the fertilization capacity with reduction of the fertilizin. The fact that fertilized eggs can not be refertilized is associated with the absence of free fertilizin in them; (7) I may add that, similarly, eggs in which membrane formation has been induced by butyric acid can not be fertilized by sperm and they contain no free fertilizin.

It is therefore very probable that the substance in question is essential for fertilization.

It may be maintained that these facts do not constitute demonstrative evidence of the necessity of this substance for fertilization, for the presence or absence or diminution of this material associated with presence or absence or decrease of fertilizing power could always be regarded as a secondary phenomenon. However, the second part of this paper dealing with the other, or ovophile side-chain of the fertilizin, strongly reinforces the argument.

Before passing on to this, I may be allowed to note some other properties of the fertilizin: In my previous papers I noted the extreme heat-resistance of the fertilizin, being only slowly destroyed at 95° C. I also noted that strongly agglutinating solutions of *Arbacia* may contain a substance which agglutinates *Nereis* sperm and stated that this was probably different from the iso-agglutinating substance. This turns out to be the case and the two can be readily separated. The substance must possess great molecular size, as it is incapable of passing through a Berkefeld filter. It is also non-dialyzable; it does not give the usual protein reactions, a fact for the determination of which I am indebted to Dr. Otto Glaser.

2. *The Ovophile Side-chain.*—Assuming, then, that the union of this substance with the spermatozoon enters in some significant way into the process of fertilization, the problem was to ascertain in what way. The simplest idea, viz., that the union is in itself the fertilization process, was soon shown to be untenable, for the reason that the perivisceral

fluid (blood) of the sea-urchin, especially of ripe males and females, often contains a substance which absolutely inhibits fertilization in the presence of any quantity of sperm, but that this substance has no inhibiting effect at all upon the sperm-agglutination reaction. It does not enter into combination with the spermophile side-chain. In other words, the binding of the agglutinin by the sperm may be complete, but in the presence of an inhibitor contained in the blood none of the usual effects of insemination, no matter how heavy, follow.

The details of the experiments upon which the above statement depends are too complex for consideration here. But they showed that the effect is neither upon the egg alone nor upon the sperm alone, for both may stand for some time in the presence of this agent and after washing be capable of normal behavior in fertilization, though there may be some decrease in the percentages. No poisonous effect is involved on either sexual element.

The next suggestion was fairly obvious, viz., that the substance which we had been calling agglutinin, on account of its effect upon the spermatozoa, is in reality an amboceptor with spermophile and ovophile side-chains, and that the binding of the sperm activates the ovophile side-chains which then seize upon egg receptors and fertilize the egg. If this were so, it is obvious that the spermatozoon is only secondarily a fertilizing agent, in the sense of initiating development, and that the egg is in reality self-fertilizing, an idea which agrees very well with the facts of parthenogenesis and the amazing multiplicity of means by which parthenogenesis may be effected. For the agents need only remove obstacles to the union of the amboceptor and egg receptor.

The inhibiting action of the blood from this point of view is a deviation effect due to occupancy of the ovophile side-chain of the amboceptor, either because the inhibitor in the blood is an anti-body to the amboceptor or because it possesses the same combining group as the egg receptor. In such a case, the ovophile group of the amboceptor, being already occupied by the inhibitor, fertilization could not take place.

Fortunately, this idea is susceptible of a ready test; for, if the blood acts in this way in inhibiting fertilization, all that is necessary to neutralize the inhibiting action would be to occupy the inhibitor by the amboceptor (fertilizin) for which *ex. hyp.* it has strong affinity. This experiment was repeated many times in different ways with various dilutions, and the result was always to lessen or completely remove the inhibiting action of the blood.

The plan of such an experiment is this: to divide the filtered blood (plasma) in two parts, one of which is used for control while the other is saturated with fertilizin by addition of eggs. In ten minutes the latter are precipitated by the centrifuge and the supernatant fluid filtered. Fertilizations are then made in graded dilutions of this and the control blood. In some cases the inhibiting action of the blood was completely neutralized, and in all largely neutralized.

The results so far are in agreement with the theory. But if it be true that the egg contains its own fertilizing substance, it might also be possible to induce parthenogenesis by increasing the concentration of this substance to a certain point; though it is conceivable that no increase in concentration would break down the resistance that normally exists to union of the amboceptor and egg receptors. As a matter of fact, Dr. Otto Glaser[2] has shown this summer that a certain amount of parthenogenetic action may be induced in *Arbacia* in this way. I have been in consultation with Dr. Glaser during part of his work and can confirm his statements.

In connection with the assumption that the sperm activates an already existing side-chain of a substance contained in the egg itself, I may be allowed to cite the following statement of Ehrlich:

> The significance of the variations in affinity will be discussed connectedly at a subsequent time. We shall content ourselves here by pointing out

[2] SCIENCE, N. S., Vol. XXXVIII., No. 978, September 26, 1913, p. 446.

that an understanding of the phenomena of immunity is impossible without the assumption that certain haptophore groups become increased or decreased in their chemical energy, owing to changes in the total molecule. Chemically, such an assumption is a matter of course.[3]

This principle might explain the activation of the fertilizing amboceptor by the sperm.

The question will of course be raised whether there is not another and simpler interpretation of the facts. There are three general classes of these facts: (1) the sperm agglutination phenomena, and the apparent necessity of the agglutinating substance for fertilization; (2) the presence of an inhibiting agent in the blood, especially of ripe males and females; (3) the neutralization of this inhibiting agent by the agglutinating agent (amboceptor). It may be questioned whether these facts have the particular causal nexus that I have given them. But I think it would be difficult to construct a theory taking account of all the facts which would differ essentially from that presented here.

The theory is really extremely simple in its character, and the facts on which it rests are readily tested. It has proven a most valuable working hypothesis; indeed, many of the facts referred to were discovered only after the theory was formed. It has the advantage of offering one theory for initiation of development whether by fertilization or by parthenogenesis. It is capable of explaining the whole range of specificities in fertilization by assuming a specific fertilizin for each species. It furnishes the foundation for the chemical conceptions necessary to any theory of fertilization, and it is susceptible of experimental test.

It will be seen that inhibition of fertilization may occur by block in any part of the mechanism.

1. Through loss of fertilizin by the egg.
2. Through occupancy of the sperm receptors.
3. Through occupancy of the egg receptors.
4. Through occupancy of the ovophile side-chain of the amboceptor (fertilizin).
5. Through occupancy of the spermophile side-chain group.

Of these I have shown the occurrence of the first, fourth and fifth in *Arbacia*. The first in the case of long-washed eggs; the fourth in the case of the inhibitor contained in the blood; the fifth is, I believe, the mechanism for prevention of polyspermy.

The mechanism of fertilization appears to be the same in *Nereis*, though I have not a complete set of data. However, the data that I have are in accord with the theory, and will be described in the complete paper.

I should perhaps state specifically that the location of the fertilizin is in the cortex of the egg.

It seems to me probable that the activation of the fertilizin is by no means confined to that bound by the single penetrating sperm, but that activation once set up spreads around the cortex. The supernumerary spermatozoa that fail to enter the egg may also play a part by setting up centers of activation. In this connection Glaser's contention that several spermatozoa at least are necessary for fertilization is of great interest. The nature of the effect of the activated fertilizin on the egg is analogous in some respects to a superficial cytolysis, in this respect agreeing with Loeb's theory. But the "lysin" is contained in the egg, not in the sperm, as Loeb thought; if cytolysis is involved, it is a case of autocytolysis. This may involve increase of permeability, the effects of which R. S. Lillie has especially studied. I mention these possibilities in order to point out that the conception contained in this paper is not in conflict with the well-established work of others.

In conclusion, I may point out that the theory assumes a form of linkage of sperm and egg components by means of an intermediate body that may find a place in the study of heredity. The detailed experiments will be published later.

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September 1, 1913

[3] "Collected Studies in Immunity," p. 220.